LWD 1

System Specifications

System Specifications

What changes during the drilling of a well that may affect the selection of an MWD system?

System Specifications

- Hole Size (Collar Size)
- Mud Flow Rate
- Mud Density
- Formation Temperature
- Bottom Hole Pressure

System Specifications

Hole Size

- Usually decreases with hole depth
  - Why?

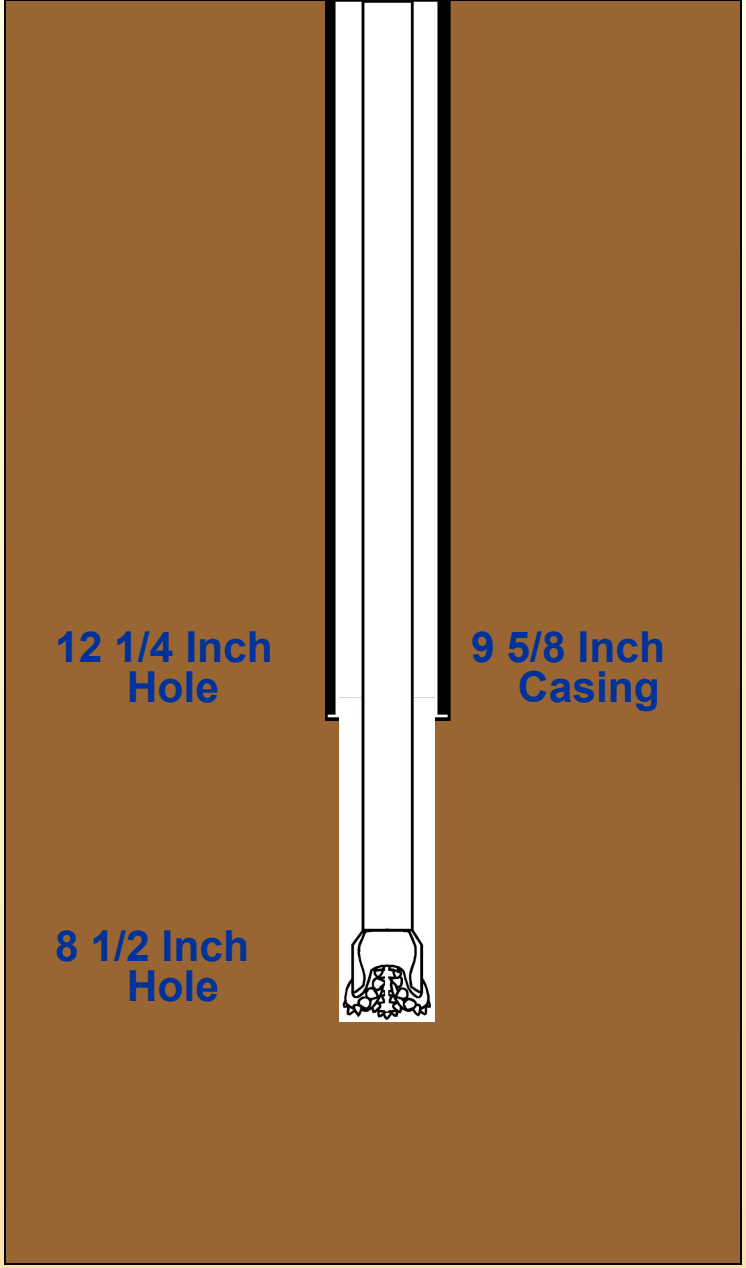
System Specifications

Hole Size

- Usually decreases with hole depth

  Why?

  - Casing or liner is run to isolate shallower hole sections.
  - A smaller diameter drill bit is then required to pass through the casing.
  - Smaller diameter drill collars are used.



System Specifications

System	Collar OD	Typical Hole Sizes
1200	7-3/4 to 11	24 to 12 ¼
650	6-1/2 to 9-1/2	8 ½ to 12 ¼
Slimhole	4-3/4	6 to 6 ½
Superslim	3-1/8 to 3-1/2	4 to 5 ?

Hole Size

12 1/4 inch hole

- 8 inch collars

Select

- 650 or 1200 System

8 1/2 inch hole

- 6-3/4 inch collars

Select

- 650 system

System Specifications

Mud Flow Rate

- Usually decreases with hole depth
  - Why?

System Specifications

Mud Flow Rate

- Usually decreases with hole depth

  Why?

  - As hole diameter decreases less flow is required to clean the hole.
  - As hole depth increases circulating pressure also increases
  - Flow is reduced to keep the circulating pressure within limits.

System Specifications

System	Flow Range gpm
1500 option	1200 to 1500
1200	400 to 1200
650	225 to 650
Slimhole	150 to 350
Superslim	
Straight	60 to 175
Undercut	100 to 220

Flow Rate

12 1/4 inch hole

- 8 inch collars
- 850 gpm

Select

- 1200 System

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm

Select

- 650 system

System Specifications

Mud Density

- Changes with hole conditions
  - Why?

System Specifications

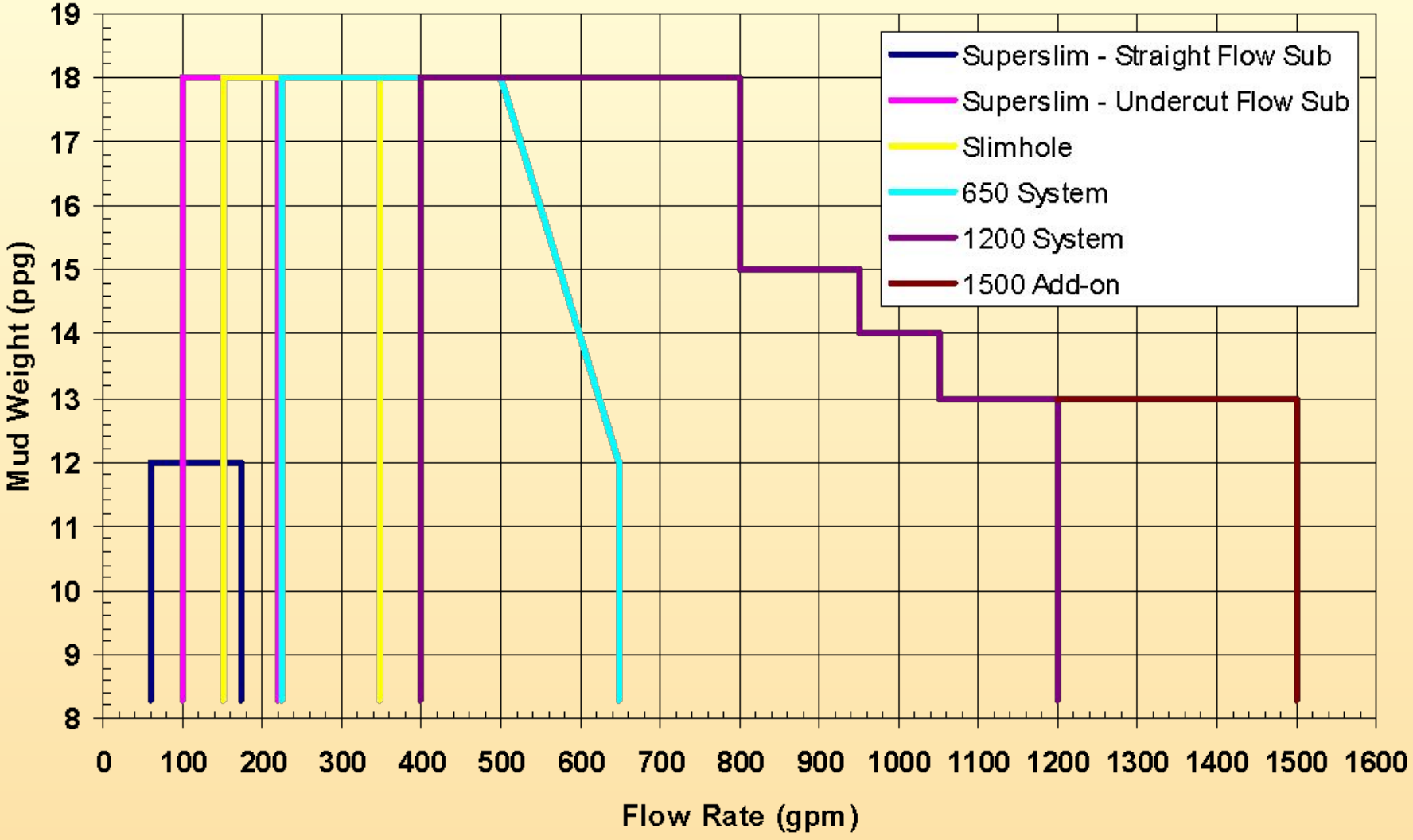
Mud Density

- Changes with hole conditions

  Why?

  - Mud density is adjusted to balance the formation pressure.
  - It usually increases with depth, but may decrease again after casing is set.

Flow Rate Envelopes



Mud Density

12 1/4 inch hole

- 8 inch collars
- 850 gpm
- 12 ppg

Select

- 1200 System

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm
- 13 ppg

Select

- 650 system

System Specifications

Temperature

- Increases with true vertical depth
  - Why?

System Specifications

Temperature

- Increases with true vertical depth

  Why?

  - Due to conductance of heat from earth's core to surface.
  - Temperature increases between 0.5°-5°C per 100 m, average 2.5°C per 100 m
  - Temperature increases between 0.25°-2.5°F per 100 ft, average 1.5°F per 100 ft

System Specifications

Temperature

- Affects the selection of:
  - Pulser

System Specifications

- **Pulser Temperature Ratings**

Pulser	Maximum Temperature
Mk VI	175° C (347° F)
Mk VII	200° C (392° F)
Mk VIII	200° C (392° F)

Temperature

12 1/4 inch hole

- 8 inch collars
- 850 gpm
- 12 ppg
- 100° C at 10,000 ft

Select

- 1200 System
- Any pulser

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm
- 13 ppg
- 145° C at 14,000 ft

Select

- 650 system
- Any pulser

System Specifications

Temperature

- Affects the selection of:
  - Pulser
  - Directional sensor

System Specifications

- **Directional Sensor Temperature Ratings**

Sensor	Maximium Temperature
DEP, DEP II	140° C (284° F)
PCD, PCD-K, PCD-R	150° C (302° F)
DM	175° C (347° F)

Temperature

12 1/4 inch hole

- 8 inch collars
- 850 gpm
- 12 ppg
- 100° C at 10,000 ft

Select

- 1200 System
- Any pulser
- Any directional probe

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm
- 13 ppg
- 145° C at 14,000 ft

Select

- 650 System
- Any pulser
- Do not use DEP/DEPII

System Specifications

Temperature

- Affects the selection of:
  - Pulser
  - Directional sensor
  - Gamma sensor

System Specifications

- **Gamma Sensor Temperature Ratings**

Sensor	Maximum Temperature
PCG, PCG-R	150° C (302° F)
GM	175° C (347° F)

Temperature

12 1/4 inch hole

- 8 inch collars
- 850 gpm
- 12 ppg
- 100° C at 10,000 ft

Select

- 1200 System
- Any pulser
- Any directional probe
- Any gamma sensor

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm
- 13 ppg
- 145° C at 14,000 ft

Select

- 650 System
- Any pulser
- Do not use DEP/DEPII
- Any gamma sensor

System Specifications

Pressure

Two components

- Hydrostatic Pressure
- Circulating Pressure

System Specifications

Hydrostatic Pressure

- Increases with true vertical depth
- Increases with increases in mud density
  - Why?

System Specifications

Hydrostatic Pressure

- Increases with true vertical depth
- Increases with increases in mud density

  Why?

  - Pressure = 0.052 x TVD (ft) x Mud Density (ppg)

System Specifications

Circulating Pressure

- Increases with hole depth.
- Increases with increases in flow rate.
- Increases with increases in Mud Density, PV, YP.
- Increases with decreases in flow area of drillstring, jets, and annulus.

System Specifications

Pressure

- What pressure is the tool exposed to?

System Specifications

Pressure

What pressure is the tool exposed to?

- Hydrostatic Pressure plus the following circulating pressure losses:
  - Pressure loss in the BHA below the tool
  - Pressure loss at the jets
  - Pressure loss in the annulus

System Specifications

Sensor Pressure Ratings

- Sondes are limited by pressure case.
- Superslim pressure cases have molded on centralizers, hence thinner walls, lower pressure rating.

System Specifications

Sensor Pressure Ratings

Sensor	Pressure	
	Standard	Superslim
DEP, DEP II	18,000 psi	15,400 psi*
PCD-R/PCG-R	20,000 psi	??,??? psi*
DM/GM	22,500 psi	16,500 psi*

*** Unofficial pressure rating**

Pressure

12 1/4 inch hole

- 8 inch collars
- 850 gpm
- 12 ppg
- 100° C at 10,000 ft
- 6,240 hyd + 1,500 circ

Select

- 1200 System
- Any pulser
- Any directional probe
- Any gamma sensor

8 1/2 inch hole

- 6-3/4 inch collars
- 620 gpm
- 13 ppg
- 130 ° C at 14,000 ft
- 9,464 hyd + 1,200 circ

Select

- 650 System
- Any pulser
- Do not use DEP/DEPII
- Any gamma sensor

System Specifications

- What other specifications are important?
  - Dogleg Severity
  - Sand Content
  - Plastic Viscocity
  - Lost Circulation Material
  - Tool Joint Torque

System Specifications

Dogleg Severity

- Rotating is the worst situation

Collar Size	Rotating	Sliding
3-1/2, 4-3/4	14°/100 ft	30°/100 ft
6-1/2 to 7-1/4	10°/100 ft	21°/100 ft
7-1/4 to 9-1/2	8°/100 ft	14°/100 ft

System Specifications

Sand Content

- Less than 2%, recommended less than 1%.
- Above 1100 gpm limited to 1% or less.

Plastic Viscosity

- Maximum 50 centipoise

System Specifications

Lost Circulation Material (LCM)

- 40 lb/bbl medium non-fibrous (nut plug) and some fine fibrous (kwik seal)
- Superslim is less tolerant to LCM
  - Straight flow sub less than 7.5 lb/bbl
  - Undercut flow sub greater than 7.5 lb/bbl

System Specifications

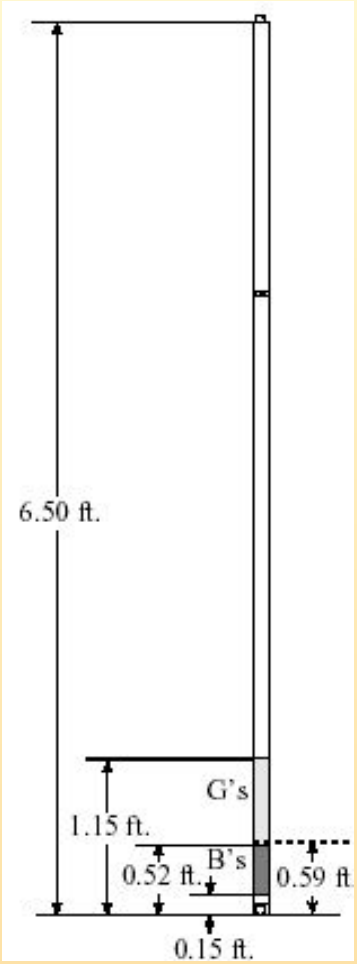
Tool Joint Torque

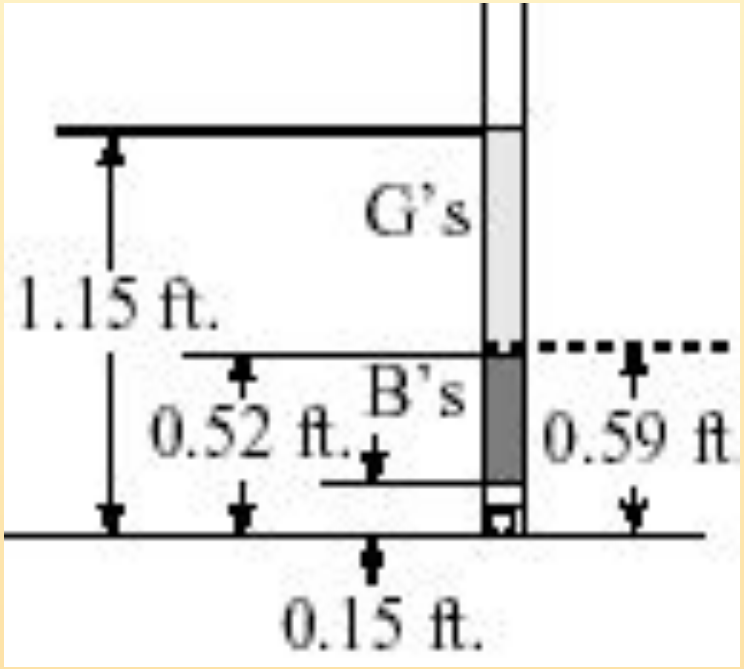
- Pin ID on positive pulse 1500, 1200, 650 System HOS/HOC's are bored-out.
- Use torque specifications for standard sizes
  - For Pin ID 2.88 inch, use 2-13/16 inch
  - For Pin ID 3.31 inch, use 3-1/4 inch
  - For Pin ID 4.04 inch, use 4 inch

Sensor Measure Point

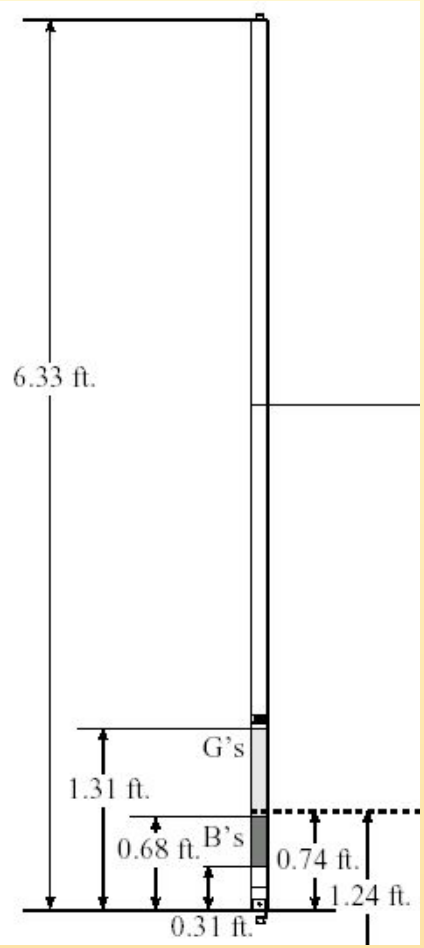
- Used to calculate sensor to bit distance
- Surveys referenced to where measurements made, not to bit
- Gamma referenced to where measurements made, not to bit

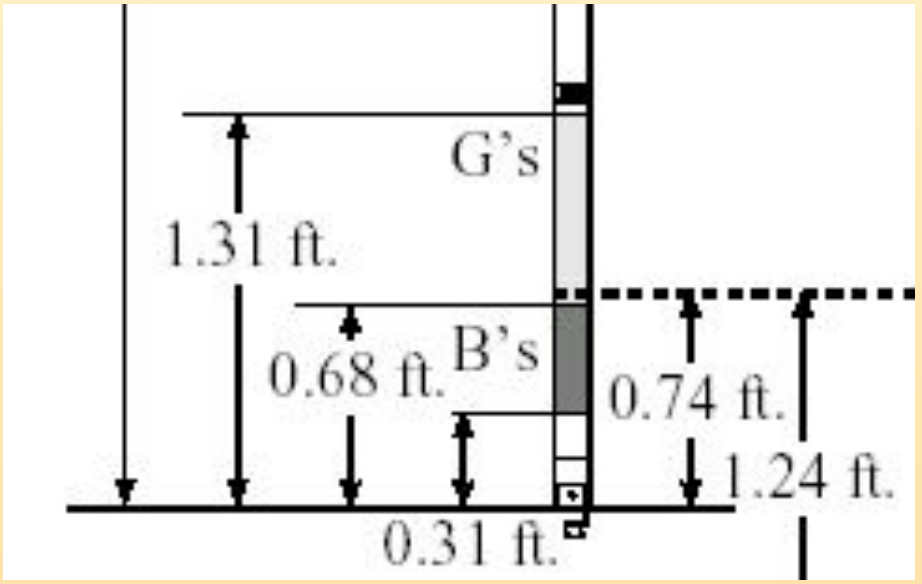
Sensor to bit distance - DEP



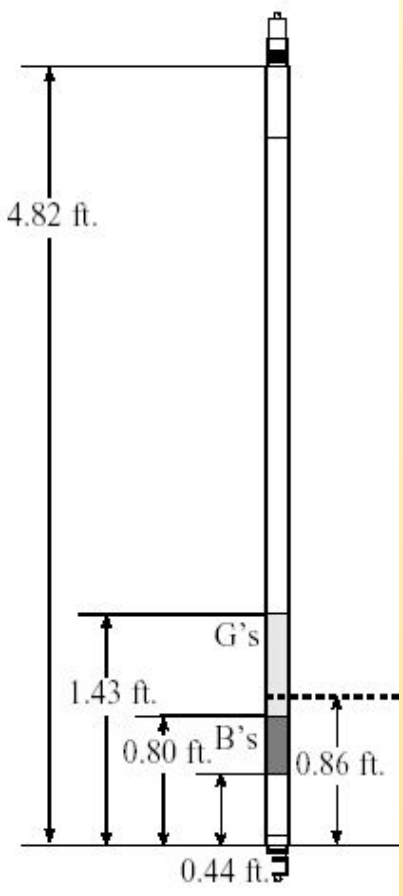


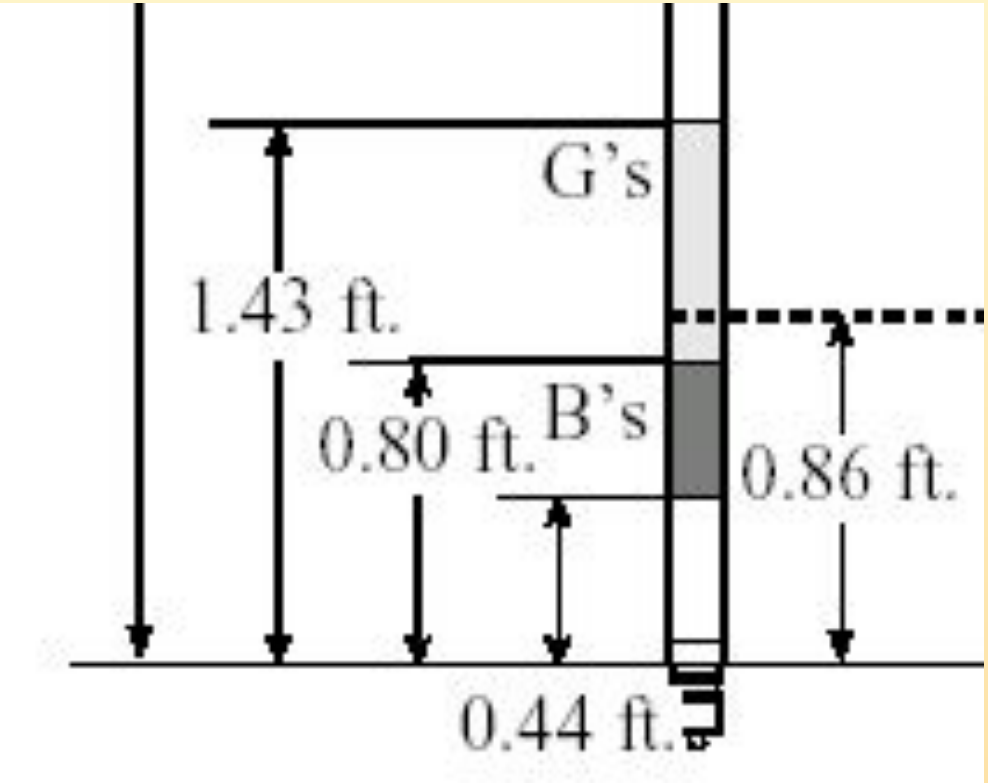
Sensor Measure Point – DEP2



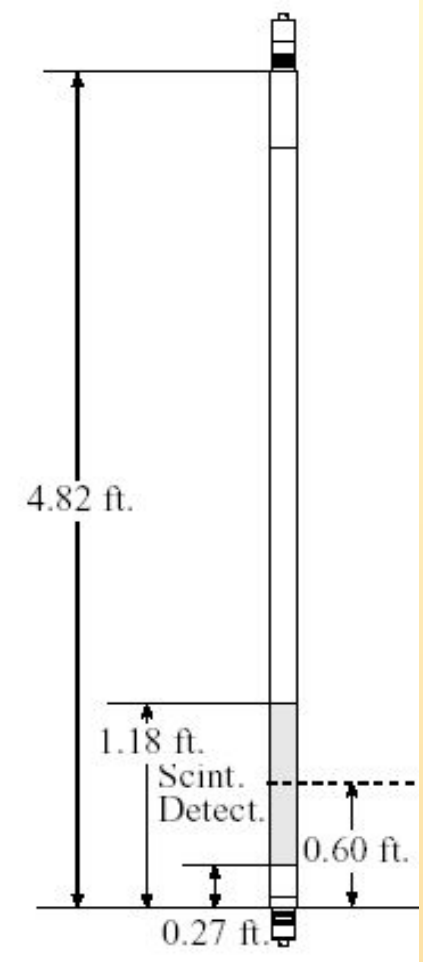


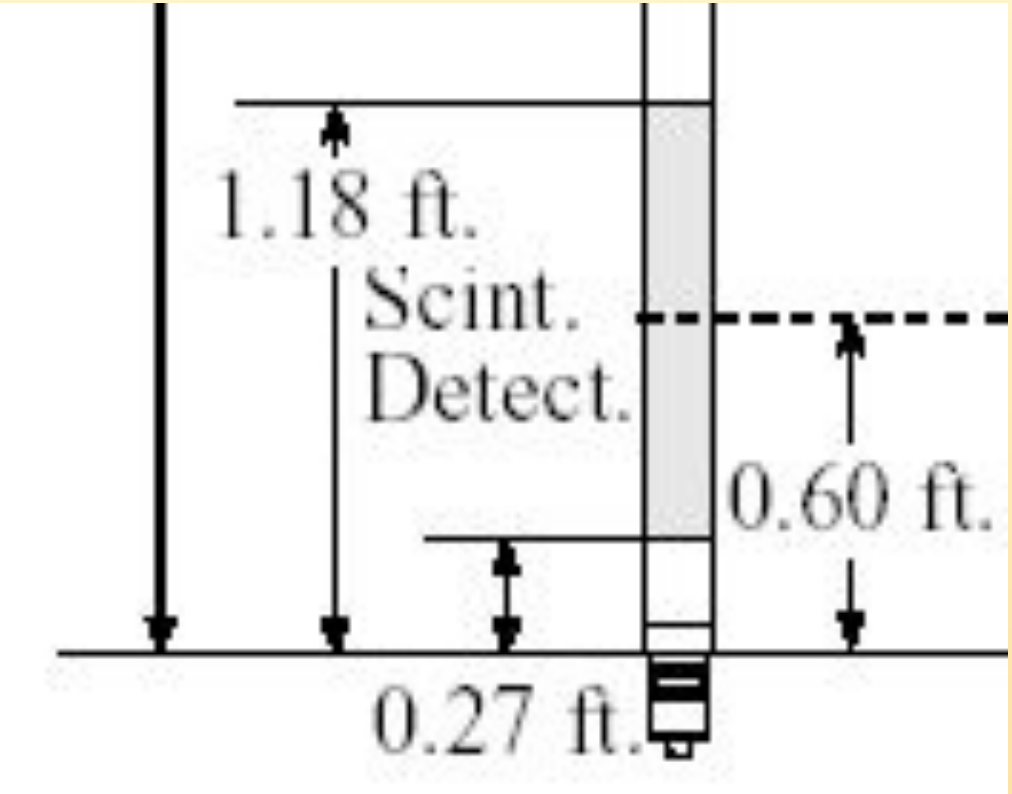
Sensor Measure Point - PCD



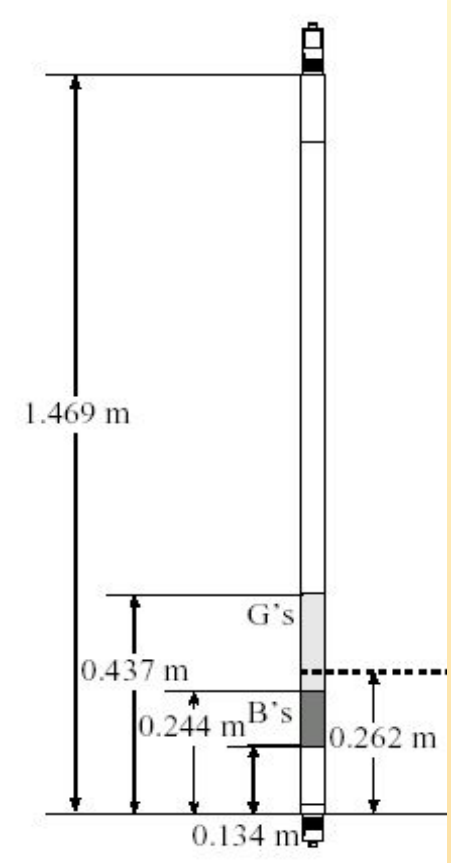


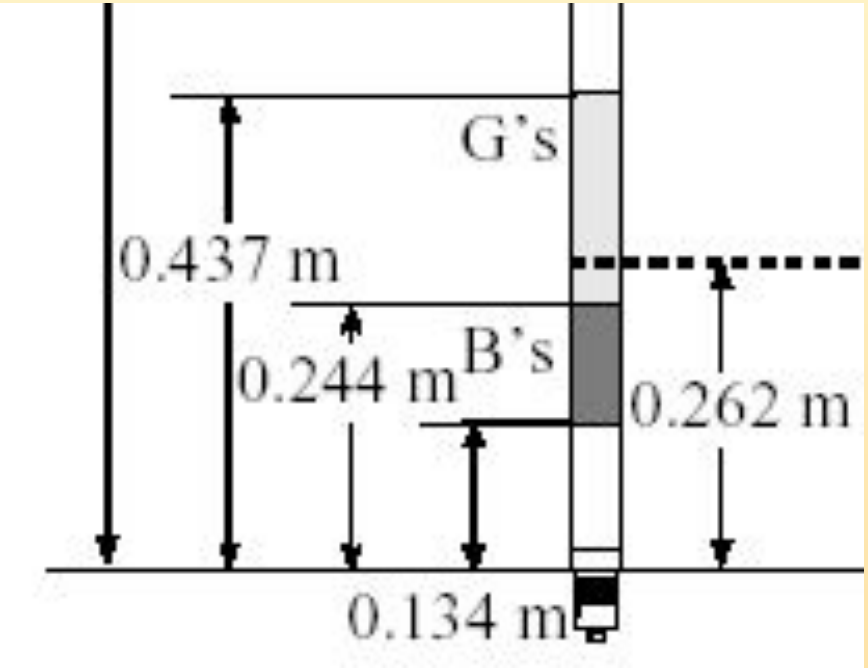
Sensor Measure Point - PCG



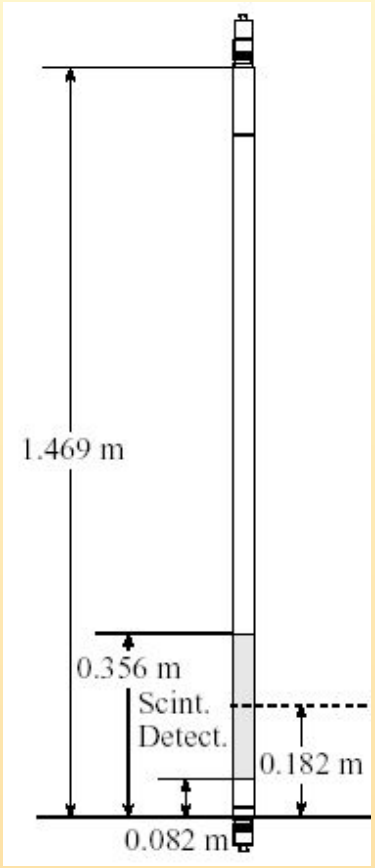


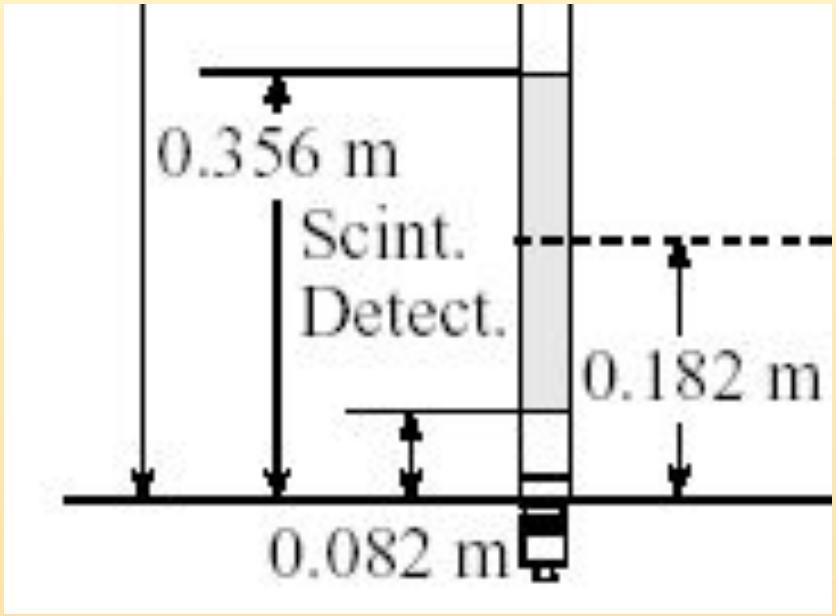
Sensor Measure Point – PCD Metric Units





Sensor Measure Point – PCG Metric Units





System Specifications

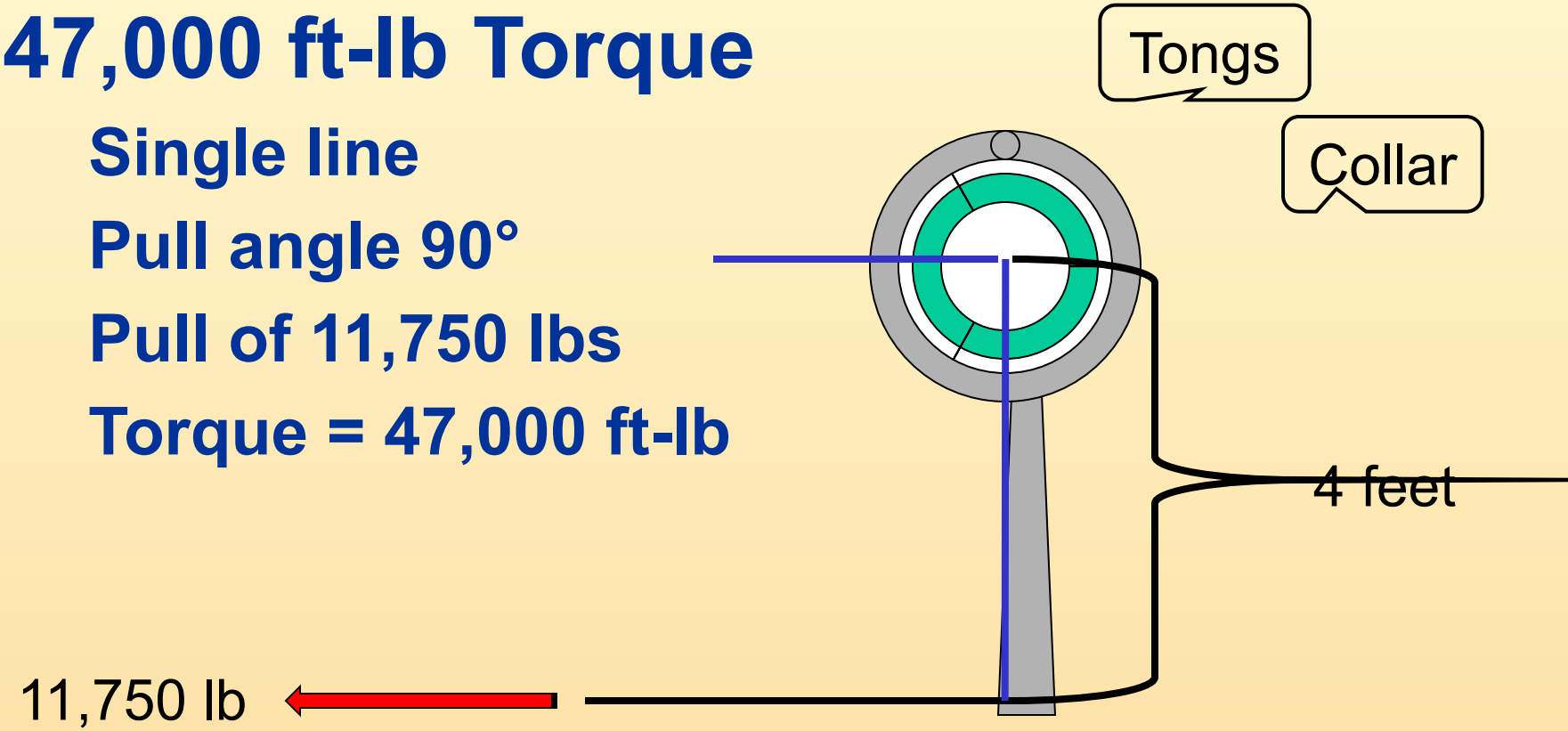
Tool Joint Torque

- How do we apply it correctly?
- For example:
  - 8 inch collar
  - 6-5/8 API Regular Connection
  - 3-1/4 inch pin bore
  - 47,000 ft-lb Torque
  - 4 foot tongs

System Specifications

47,000 ft-lb Torque

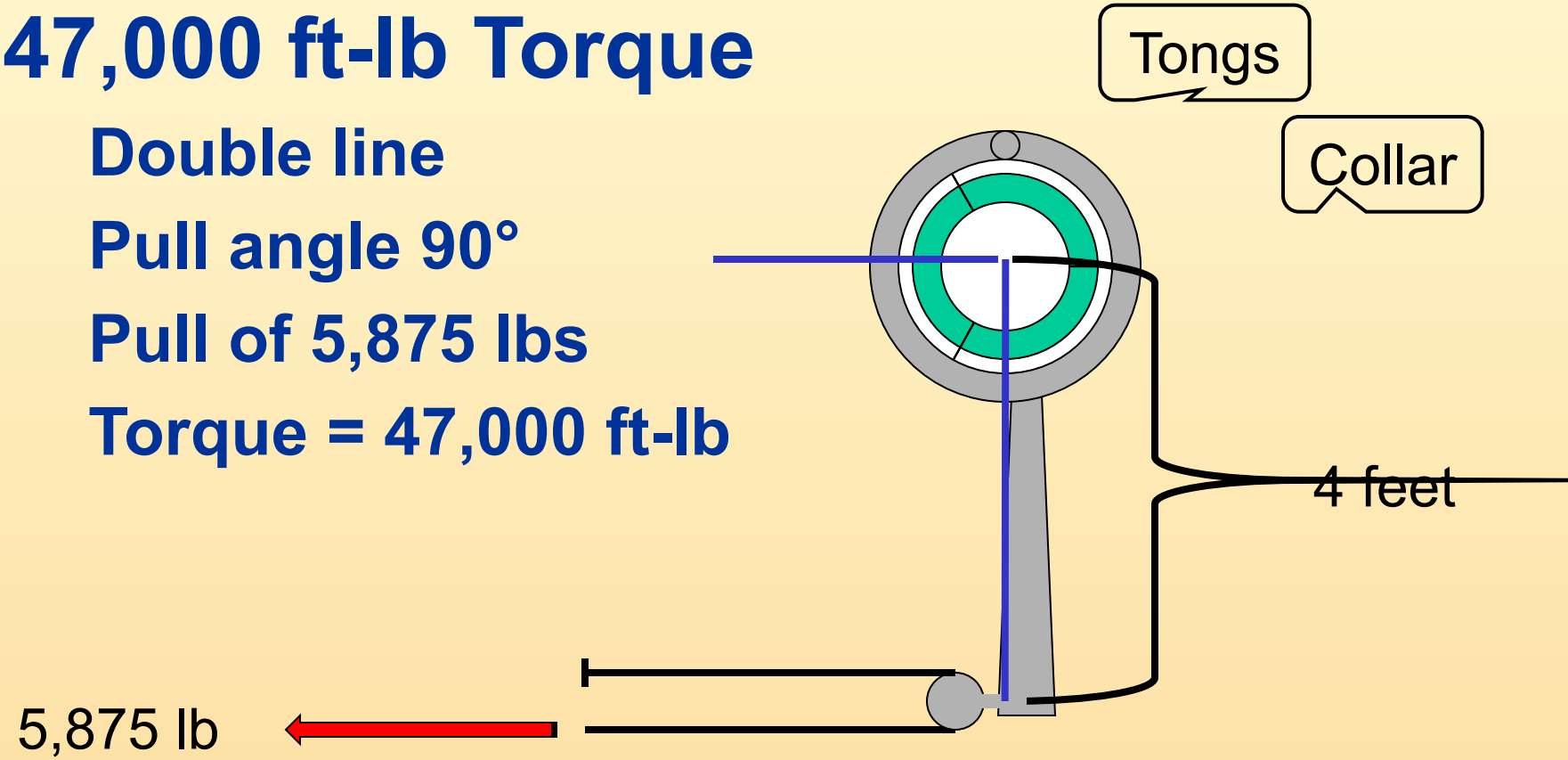
- Single line
- Pull angle 90°
- Pull of 11,750 lbs
- Torque = 47,000 ft-lb



System Specifications

47,000 ft-lb Torque

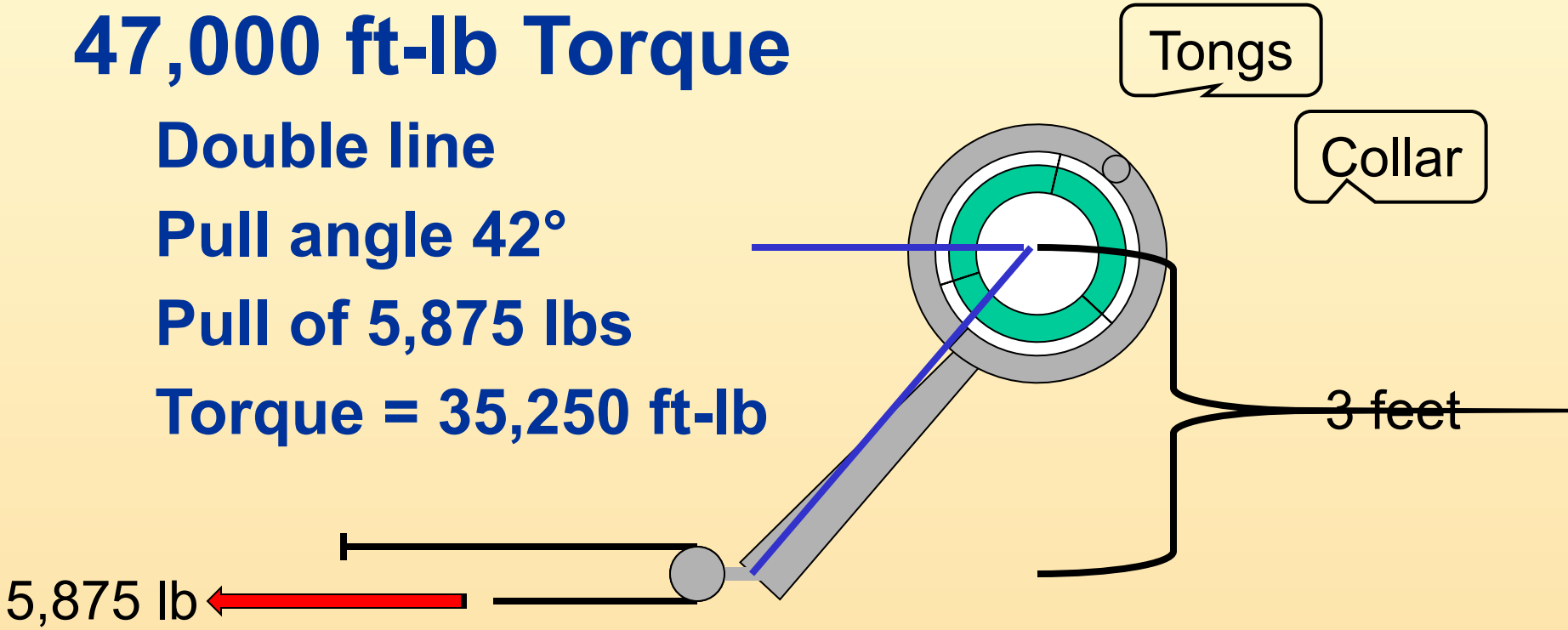
- Double line
- Pull angle 90°
- Pull of 5,875 lbs
- Torque = 47,000 ft-lb



System Specifications

47,000 ft-lb Torque

- Double line
- Pull angle 42°
- Pull of 5,875 lbs
- Torque = 35,250 ft-lb



System Specifications

47,000 ft-lb Torque

- Double line
- Pull angle 42°
- Pull of 7,833 lbs
- Torque = 47,000 ft-lb