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Design And Fabrication Of A Prototype Offshore Blowout Preventer(Bop) Stack

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***Abstract*—One of the first pieces of safety equipment designed for oil and gas production, the blow out preventer(BOP) is a large valve at well that can be closed if the drilling crew loses control of oil or natural gas while drilling or performing a work over. If theses fluids manage to enter the wellbore, they may threaten the safety of the rig and crew. The BOP is designed to either close an open wellbore, seal around tubular components in the well, or cut through drill pipe. The Blowout preventer come in two basic types on this design: They are Annular Preventers and Ram Preventers. The annular Preventer has its outer length dimension of 500m and its inner length of 440mm, breadth of 250mm seating on a connector of head flange 50mm thickness of length 350mm with same 350mm dimension making the bottom flange. At the top flange where it carries the annular Preventer and at the bottom edge where it becomes the head of the Shear Ram. The Pipe Ram, Blind Ram and Shear Ram dimensions is as follows: Pipe ram and Blind Ram welded together making a total length of dimension 790mm(a semicircular opening created);this entity gives room to close annular space. It has an integral Choke and Kill lines where fluid passes through to kill the well pressure in case of fluid entering well bore. The choke and kill lines has a diameter of 200mm. The shear ram has a total length of 420mm with hexagonal arms of 275mm length attached to the shear ram and Pipe ram. Attach on the hexagonal arm are short pipes of length 200mm cut on the hexagonal arms along the ram sections.**

Keywords—Annular Preventer, Blind Ram, BOP, Fluid, Pipe Ram and Shear Ram.

Introduction

Blowout preventer is a large, specialized valve or mechanical device usually installed redundantly in stacks used to seal, control and monitor oil and gas wells. Blowout preventer are design to control underground pressure that may reach the surface and cause a blowout. The BOP stack consists of several different devices that either close in the annulus or open wellbore or close in around or shear the drill pipe string.

The blowout preventer on an oil rig is controlled by series of pressure vessels, valves and lines. An accumulator as seen below consist of control and pressure vessels that kept charged to control thin rams and valves on the BOP stack. Some of these accumulators can be quite large on modern drilling rigs, unlike the small one below which pulling unit. BOPs are used on land well, offshore rigs, and subsea well. Land and subsea blowout preventer are secured to the wellbore known as the wellhead. BOPs on offshore rigs are mounted below the rig deck. Subsea preventers are connected to the offshore rig above by a drilling riser that provide a continuous pathway for the drill string and fluid emanating from the wellbore in effect a riser extends the wellbore to the rig. (David, 2010).

Blowout preventer were developed to cope with extreme erratic pressure and uncontrolled flow (formation kick) emanating from a well reservoir during drilling. Kick can lead to potentially catastrophic event known as a BLOWOUT. An addition to controlling the downhole (occurring in the drilled hole) pressure and the flow of oil and gas. Blowout preventers intended to preventing tubing (e.gdrill pipe and well casing), tools and drilling fluid from being blow out of the wellhore(also known as bore hole, the hole leading to the reservoir) when a blowout threatens. Blowout preventers are critical to the safety of crew, rig (the equipment system used to drill a wellbore) and environment and to the monitoring and maintenance of well integrity: thus blowout preventers are intended to provide fail-safety to the system that include them. (Collins, 2006)

Pressure control system otherwise known as a Blowout Preventer is a one of the primary function of drilling fluid is to prevent the flow of formation fluid into the wellbore. This formation fluid can either be water, oil, gas or the combination of these fluids. Weight of mud must be heavy enough to provide an overbalance for safe withdrawal pipe, but this also much not be so heavy as to cause lost of circulation or impede the penetration rates.

When a permeable formation is drilled that has fluid pressure in excess of the hydrostatic pressure exerted by the mud Colum, formation fluids (gas, oil or water) begins to flow into the wellbore. This flow of the formation fluid into the wellbore is known as KICK and this can be controlled by the well control system before the condition becomes more pronounced. However failure of the well control system to put the

dangerous signal under control result into uncontrolled flow of the formation fluid even to reach the surface is the most spectacular expensive and hazardous part of drilling (Ayodele, 2003). A blowout preventer system should allow for movement of the drill string in or out of the well under pressure. This pipe movement is called “stripping” and is done by allowing a small amount of the wellbore fluid under pressure to escape past the preventers as the pipe is moved. This reduces frictional wear on the sealing element by lubricating it. (Wikipedia, 2000).

Objectives of the work:

1)The Use of 3D AutoCAD of the design as working guide.

2)Material Selection; Used of Mild Metal (Steel Material) to Construct and Fabricate the Model.

Scope of The Design and Fabrication

The project covers the use of AutoCAD; an engineering working drawing which is a guide to achieve the fabrication and construction of the system through material selection at the Olusegun Obasanjo Centre for Engineering Innovation of the Federal Polytechnic Ado Ekiti where Lathe, Folding, Drilling, Milling ,Cutting and some other machine were utilized in achieving the assembly.

Materials And Methods

The following are materials and equipment use for the construction of the bop stack model;

The bop stack was design designed using autographic design; some of the equipment used in in fabricating the various parts of the bop stack is as follows:

- Folding machine
- Drilling machine
- Welding machine
- Cutting tools such as cutting disc, grinding stone

The materials used are 25mm mild steel pipes, 3mm Plate, Packets of Electrode, red oxide paint, bolts and nuts, 15mm steel pipe for Connector make up, 4mm plate for hexagonal arm length, Three Oxy acetylene gas cylinders used.

Welding Machine; the welding machine used in fabrication is electric arc welding machine which has its main source from electricity and makes use of electrode. Welding is a fusion process in which welding rod is coat into the previously fixed space between the metal to be joined (shapman, 1996).

Drilling Machine; the machine was used to produce hole in some parts, in order to facilitate bolting in some parts of the bop stack.

CUTTING MACHINE; the machine was used in cutting the material into the required size.

Table 1: Dimensions For Construction/Fabrication

S/N	COMPONENT	SPECIFIED DIMENSION(mm)
1	Annular Preventer Length(Outer)	550
2	Annular Preventer Length(Inner)	440
3	Annular Preventer Height	250
4	Pipe Ram Length	395
5	Pipe Ram Height	790
6	Shear Ram Length	400
7	Shear Ram Height	420
8	Connector Length	350
9	Connector Height	250
10	Full Height of the BOP Stack	1710

DESIGN PARAMETERS: The following Parameters are considered in the design:

1)Well Realted Factor

Depending on the reservoir pressure of the well, the higher the reservoir pressure, the higher the rate of kick that could occur, then the average reservoir must be established through pressure survey to know the rating of the BOP that can control such well. In this proposed design, the BOP is designed to withstand a pressure rating of 3000psi.

2)Inside Facility Rating

a)Piston Ram Rating And Packing Unit(Moving Parts).The ram position indicator allows the visual and positive indication that the rams are: open, closed, or closed and locked. Compatible with Shear, Pipe or variable bore rams.

b)Hydraulic Fluid Properties: Extremely dilute, environmentally friendly water- based hydraulic fluids must be used due to the discharge into the ocean to prevent back- pressure on the vent circuit.

c)Accumulator Capacity: This canister component remotely actuates hydraulic pressure on the BOP, store fluid sent from the rig. During emergency pressurized fluid from this canister can provide force to power the blind shear ram.

3)Centering Of Drill String And Ram Extension Configuration: Centre and hang off the drill string in the wellbore

4)Wedged Faced(Conical Faced) Piston: Annular preventer uses the principle of a wedge to shut in the wellbore, It has a donut-like rubber seal, known as elastomeric packing unit, reinforced with steel ribs .Situated in the BOP housing between the head and hydraulic piston. When the piston is actuated, its upward thrust forces the packing unit to constrict, like a sphincter, sealing the annulus.

5) Dual Pod Control System: An operable dual – pod control system to ensure proper and independent operation of the BOP system.

Fabrication Of The Bop Stack Model

The construction of the prototype BOP stack was carried out at the Obansanjo Engineering Innovation center, Federal Polytechnic Ado Ekiti workshop.

The BOP STACK was made from a Mild Pipes(Steel) of 25mm thickness which makes up the annular Preventer unit, the three ram sections and the connector made from 15mm pipe. Cutting was done using oxy acetylene gas cutting machine and folding the metal sheet of 3mm plate for the hexagonal arms attached to the 25mm pipes making up the ram sections. This five major components(Annular Preventer, Connector, Pipe Ram, Blind Ram and Shear Ram) make up the BOP STACK using folding machine, and subsequently welded to the shape of the BOP STACK.

Table 2: Describing The Selected Materials

S/NO	Components	Selected materials	Reason for selection
1	Annular preventer	25mm metal pipe in thickness	Contains packing elements that seals around the drill pipe.
2	Pipe ram	25mm metal pipe in thickness	Has a semi-circular opening that seal of around drill pipe.
3	Shear ram	25mm metal pipe in thickness	Has a semi-circular opening with a cutting edge that can shear off the drill pipe.
4	Blind ram	25mm metal pipe in thickness	It does not have a semi-circular opening; the face of the element is flat.
5	Connector	15mm mild steel pipe thickness	This Connects the Annular Preventer to the Ram Sections

DISCUSSION

Discussion Of The Bop Stack

The BOP stack fabricated with a metal mild pipe of thickness 25mm as shown in table 2 below which is used to fabricate the Annular preventer, Pipe Ram, Blind Ram and Shear Ram, 3mm mild steel plate to make the hexagonal arm attached to the three ram sections, Red Oxide as a base paint to reduce corrosion, bolt and nut and 12mm plate used as hexagonal arm.

Analysis showed performance with the installation of the annular preventer, shear ram and blind ram. It was worked over to install ram extension configuration as well as to accommodate drill string.

The expected outcome of the activity of ram extension configuration is for sealing and a semicircular opening that could shear off tubular and casing section in the place

The activity of the annular preventer with the elastomeric packing unit installed (conical paced) gave an expected outcome when actuated, the packing element seal off around the annulus to prevent pressure influx

Table 3: **Result Showing Details of Dimension of Components**

DATA	UNITS	VALVES
Metal Pipe thickness for Annular Preventer and Ram Sections	mm	25
Mild Steel Pipe thickness for Connector	mm	15
Mild Steel Plate thickness for hexagonal arm	mm	12
Annular preventer height	mm	250
Annular preventer length	mm	440
Packing element	Nil	Nil
Shear ram circular radius	mm	395
Shear ram height	mm	790
Pipe ram length	mm	395
Pipe ram height	mm	790
BOP stack total height	mm	1710
Shuttle valve	mm	50
Piston	mm	20

Activity And Output: Details of output from the project i.e result obtained from the study.

Table 4: **Table Showing Expected Outcome**

ACTIVITY	OUTCOME
Shuttle valve for blind, shear and pipe ram, piston ram, packing unit, hydraulic fluid and accumulator being designed and installed	The corresponding shear, blind and pipe ram can be operated. Thus effect the operation of shut-in.
Ram extension configuration and centering drill string	The ram section of the BOP as a section for sealing annular and a semicircular opening that could shear off tubular and casing section is in place
Annular preventer installation with the elastomeric packing unit installed (conical faced) pressure safety valve installation with flange and gasket installation	When actuated the packing element seal off around the annulus to preventer pressure influx

Conclusions and Recommendations

Conclusion

From the studies of fabrication of BOP stack through construction method, the following conclusion can be reached;

(1)Design and fabrication is the best approach through detailed drawing to produce a workable, functional and a teachable model of a BOP stack suitable for institution and some allied industries

(2)The fabrication and construction carried out was that shuttle valves was installed at a respective locations as for pipe ram and shear ram sections to actuate the semicircular section for sealing the wellbore

(3)The fabrication was actualized, showing the annular preventer, shear ram and pipe ram with the piston ram attached to the sections

Recommendation

Any BOP stack fabricated and designed must be able to make up with the investment returns for these reasons, the optimal oil productions and longer life of the well must be given a high priority.

The following recommendations are hereby suggested from the study:

(1) A suitable working detail drawing (Auto CAD 3D) should be draw for the anticipated job

(2) The design data should be carefully studied before using it to design the various explored view i.e. annular preventer, shear ram and soon

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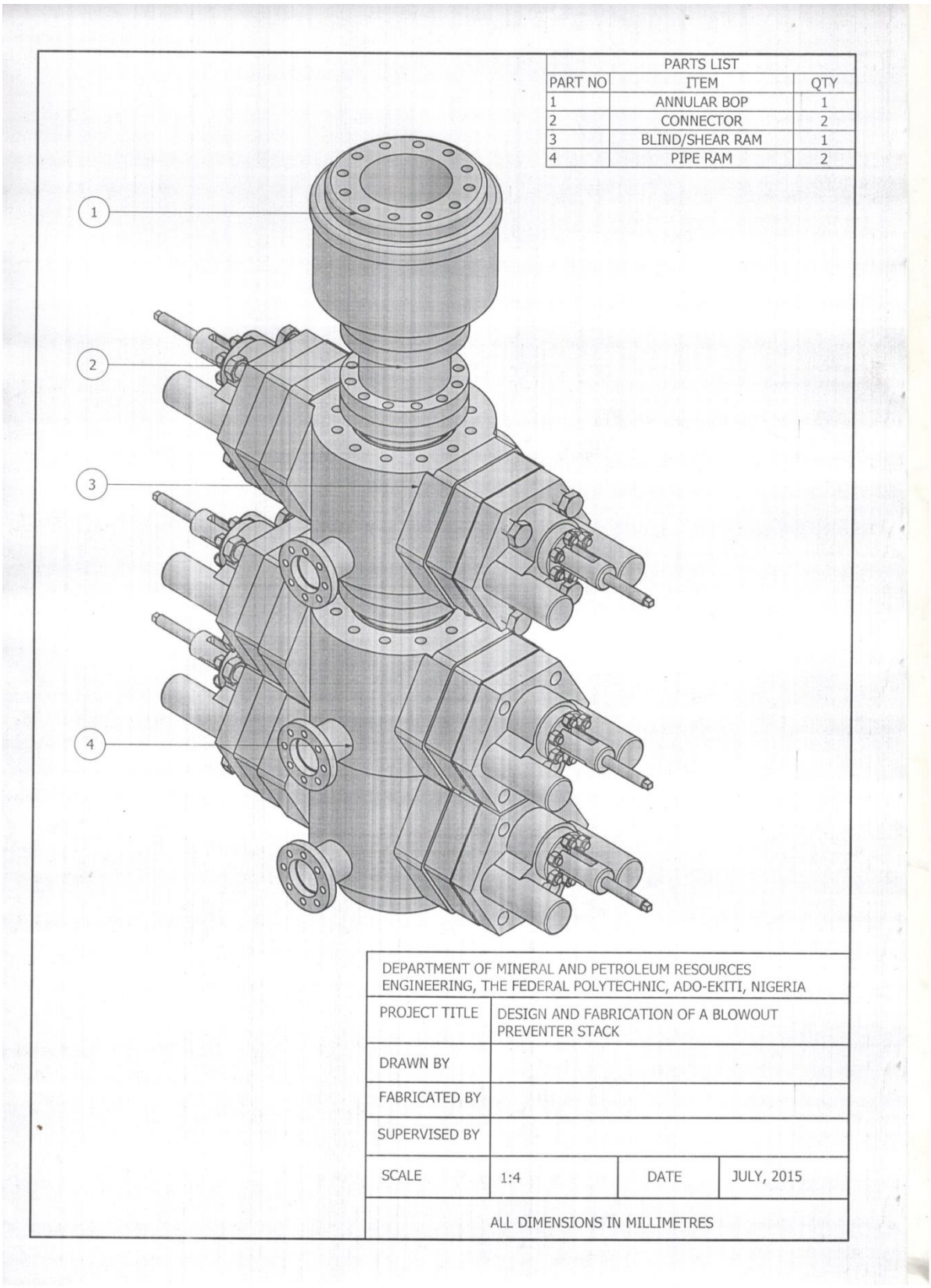

Figure 1. The Isometric View Of The Bop Stack.

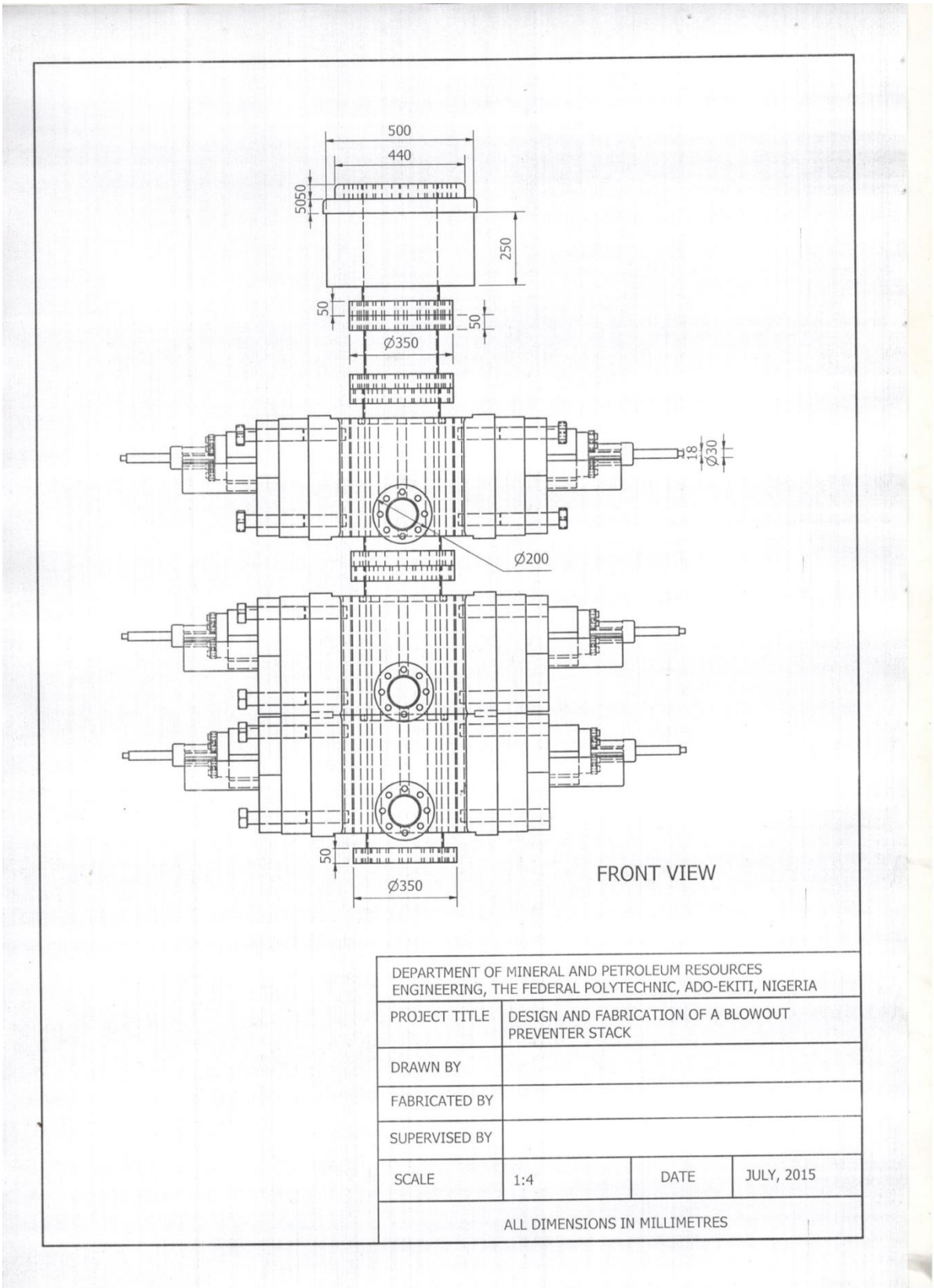

FIG 2 Showing The Fron View

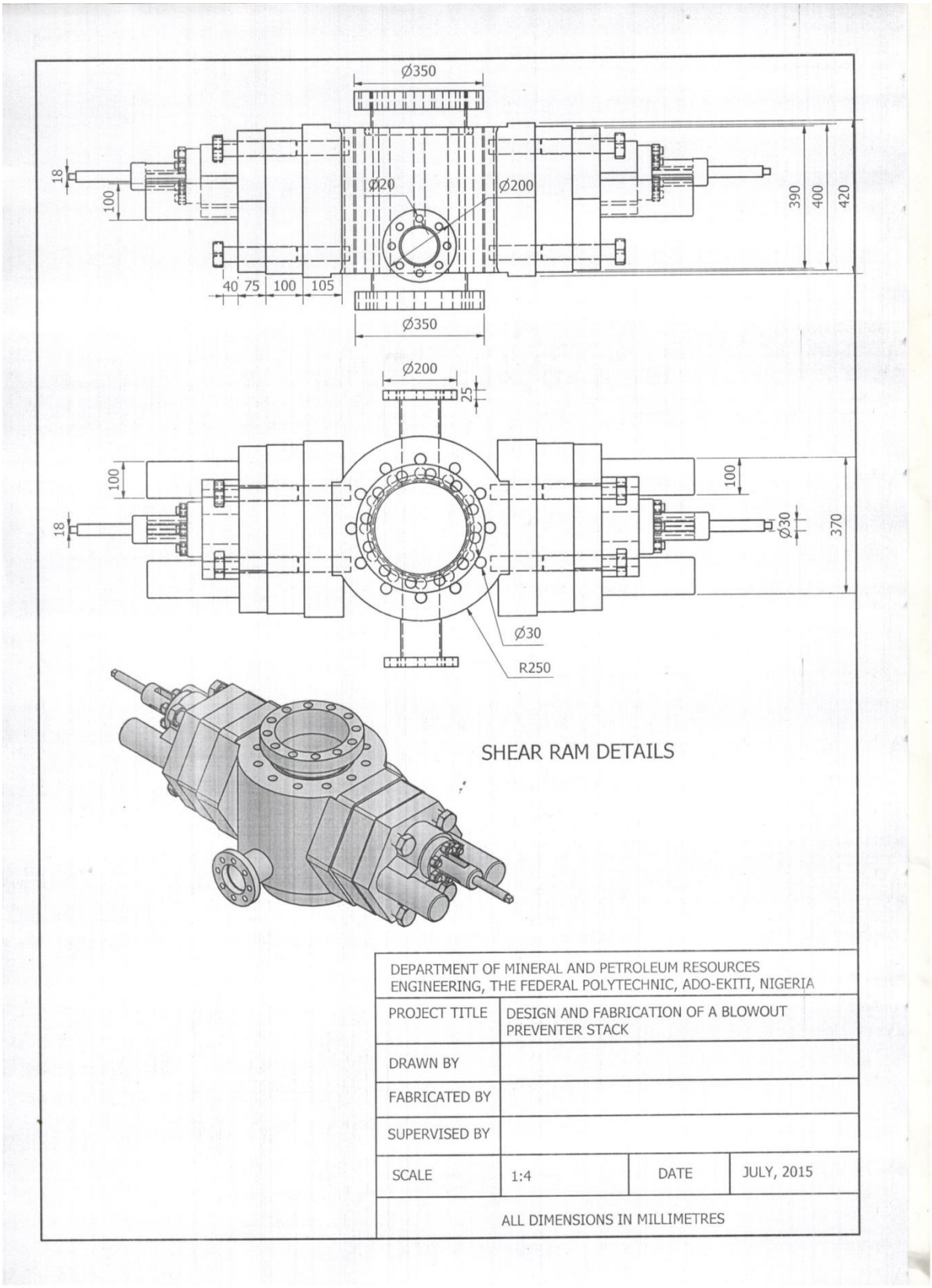

FIG 3: Shear Ram Details

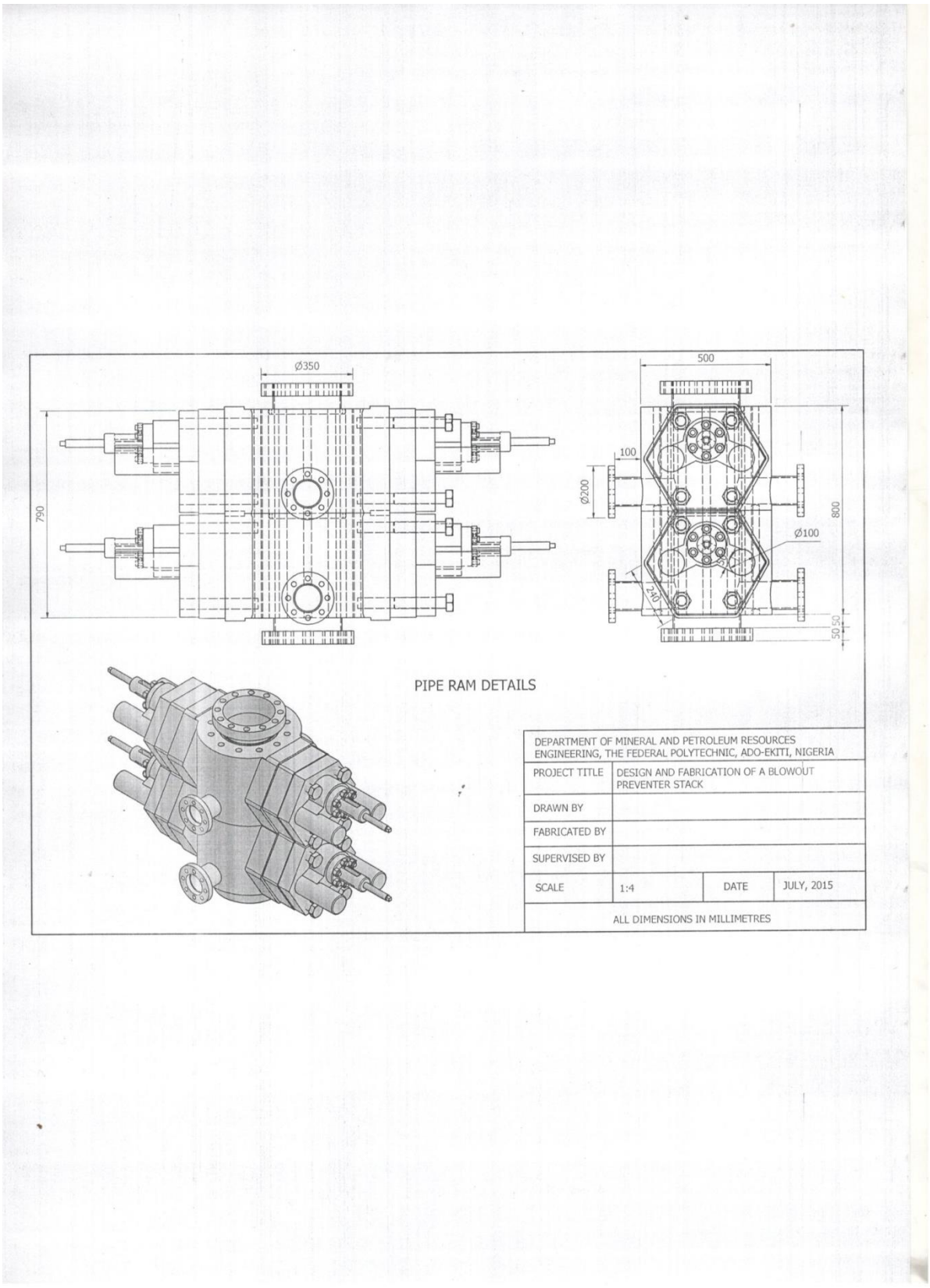

FIG 4: Pipe Ram Details

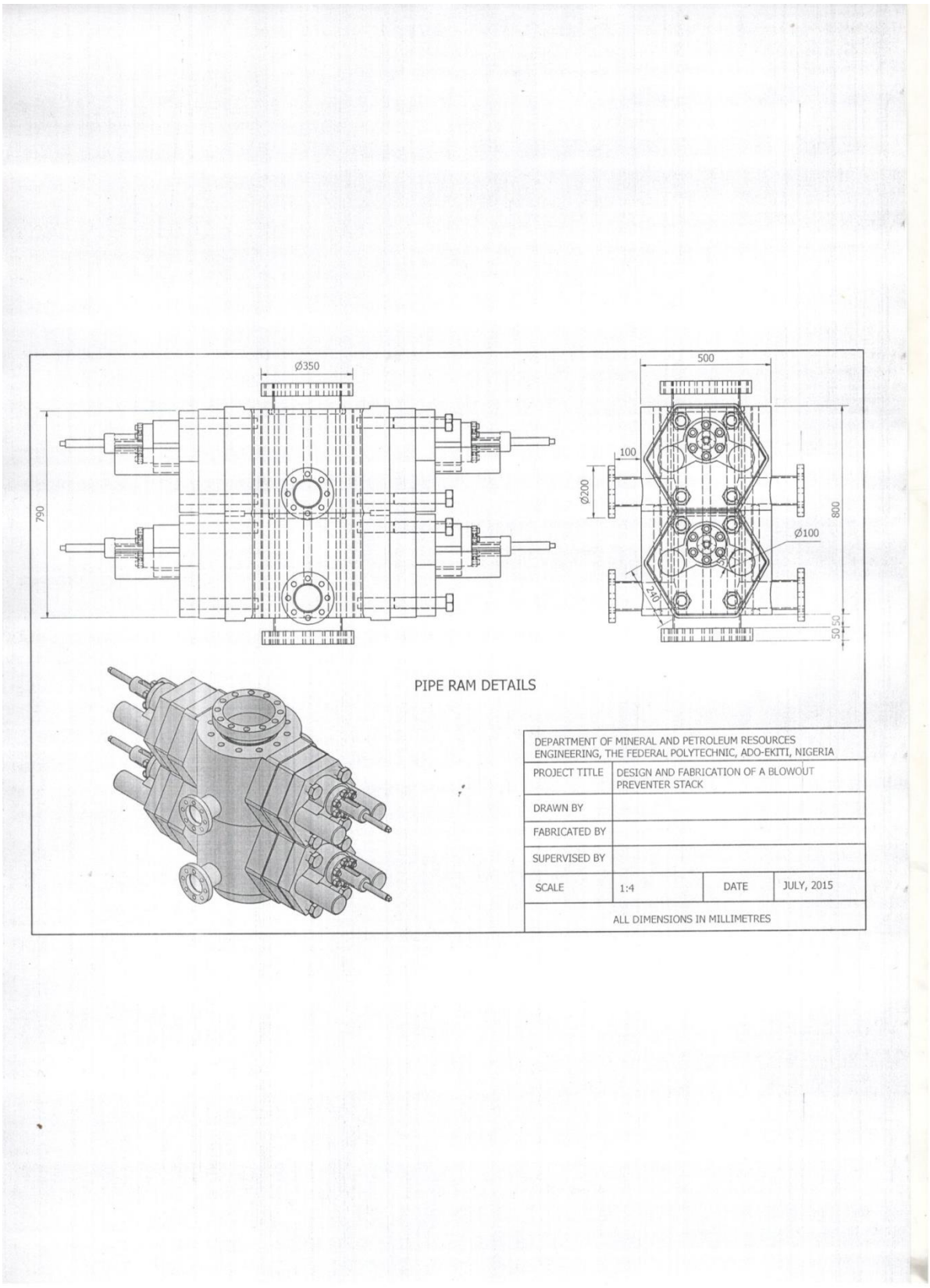

FIG 5: Side View

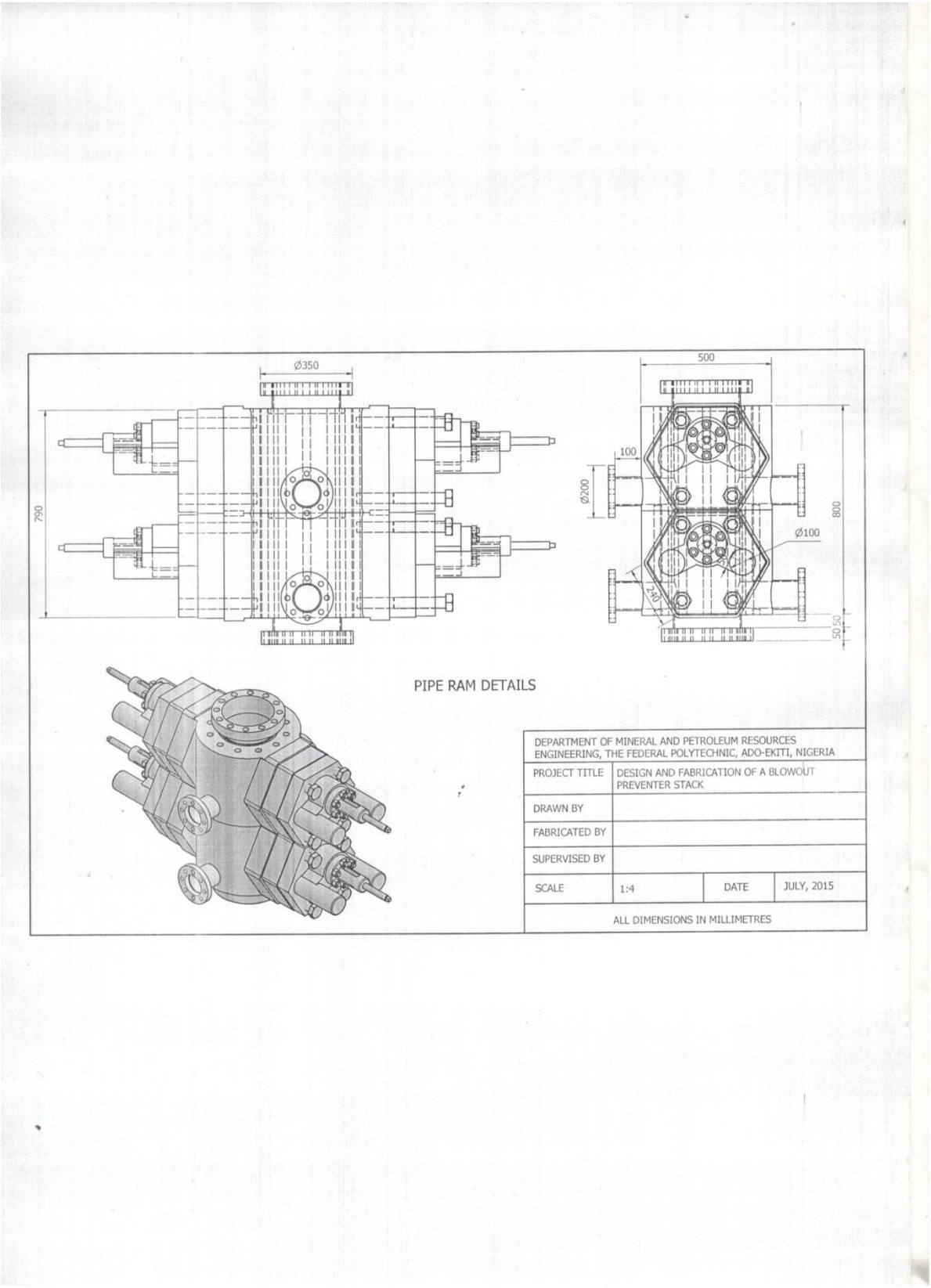

FIG 6: Connector Details.