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New ESP bypass technology simplifies installation & reduces rig time.

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Abstract

ESPs are a common form of artificial lift but when installed in a well bore access to the reservoir is blocked. The ESP must be pulled from the well to enable reservoir operations to be performed. In most ESP wells this means an alternative lift arrangement has to be temporarily used to enable production logging operations to be performed.

In 1987 the ESP bypass system, or “Y-tool”, was introduced. The bypass system is used to gain access to the reservoir below the ESP without the need to workover the well. The ESP is offset in the well bore and bypass tubing run alongside in line with the production tubing. Access is obtained using slickline, wireline or coil tubing through the bypass tubing.

The technology of the bypass system has changed little since its introduction. Although relatively simple in concept the bypass completion can be quite complex to design to ensure the assembly fits with the ESP and within the well bore. The method of assembling the ESP and bypass assembly on the rig floor varies with completion length and available pick up height in the derrick. If the ESP assembly is longer than the pick up height of the derrick the ESP and bypass tubing strings will require building in unison. As the bypass tubing typically has flush joint connections the support of the tubing during assembly is complicated and involves the use of a friction clamp and rig tugger line. The addition of a regular bypass system can greatly increase the installation time of the ESP completion and also add significantly to the risk of dropping equipment downhole.

A new technology design of bypass system with saddle assembly has improved the way ESP bypasses are installed removing the need for space out calculations prior to commencing the job, simplifying rig floor assembly and reducing the risk of lost equipment downhole. Field installations using the bypass saddle have shown rig time savings of 50% or more over traditionally assembled bypass systems.

Thermal expansion of an ESP assembly, solidly clamped to a bypass tubing string may cause strain on the equipment components as it expands. This may lead to excessive strain and possible breakage of the bypass clamp bolts. The new technology allows for independent thermal expansion of the ESP and bypass tubing alleviating unwanted stresses in system components.

Introduction

An ESP bypass system is a relatively simple completion concept enabling operations to be performed below the ESP without the need to pull the pump from the well bore. Production logging operations can be performed using the ESP to lift the well whilst logging tools are reciprocated through the bypass to gather essential production information. The bypass system uses a "Y-tool" to offset the ESP in the well bore. Bypass tubing is run in parallel to the ESP string to provide a conduit for logging operations. A blanking plug is installed below the Y-tool in the bypass leg to prevent recirculation of fluid when the ESP is producing. Bypass clamps are typically used to secure the bypass tubing string alongside the ESP. Bypass clamps also provide clips to protect the Motor Lead Extension (MLE) and any control lines whilst running in hole.

Installation of the bypass system can add significant time to the assembly of the ESP due to the extra completion equipment that must be built in parallel with the pumps and motors. The installation procedure will depend on the length of the ESP assembly and the pick up height available in the derrick.

The bypass string typically has flush joint tubing to enable the maximum ESP size to be run and provide the maximum ID of bypass tubing. During assembly a friction clamp is utilized to hold the bypass tubing on the worktable.

Once installed, bypass clamps secure the bypass tubing to the ESP string. The ESP and bypass tubing expand at different rates as their temperature rises. Differences in expansion between the ESP and bypass tubing will increase when the ESP is started and generates its own heat.

This paper discusses a new technology which simplifies the installation procedure and allows the ESP to expand and contract independently of the bypass tubing.

Background - Conventional Bypass System Installation

A conventional bypass system typically consists of a handling sub, Y-tool, pump sub, bypass tubing, bypass clamps and teleswivel nipple. The length of the assembly from the top of the handling sub to the lowest bypass clamp must be checked against the pick up height available in the derrick to ascertain how the bypass will be installed. (Figure 1)

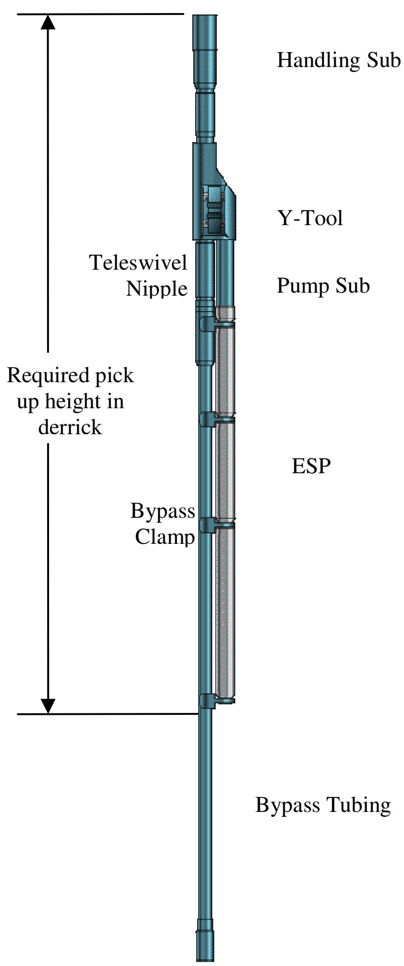

Figure 1 – Conventional Bypass System

If the derrick is not of sufficient height to allow the bypass and ESP to be picked up to the lowest bypass clamp, the system will require a space out check and a complicated build procedure.

1. Tally ESP lengths and Bypass tubing lengths.
2. Ascertain where the ESP necks will be in relation to the lengths of bypass tubing when assembled.
3. Mark up the bypass tubing with ESP neck positions.
4. Ascertain the maximum length of bypass and ESP that can be picked up in the derrick
5. Build up an appropriate length of bypass tubing on worktable
6. Build up an appropriate length of ESP assembly on worktable
7. Pick up the ESP string in the elevators and the Bypass string on a tugger line to allow fitment of bottom bypass clamp to motor base
8. Align predetermined space out marks for ESP necks on bypass tubing with ESP necks
9. Fit lower clamp.
10. Lower both ESP string and bypass tubing string in unison. The tugger line and elevators must be simultaneously lowered to avoid changing the alignment.
11. Keep the bypass tubing marks lined up with the ESP necks. Do not allow the bypass to slip. (Figure 2)
12. Connect ESP Cable to motor.
13. Fit Bypass Clamp at ESP neck
14. Continue to lower both ESP string and bypass tubing string in unison until the ESP lifting clamp lands on the work table.
15. Keep the bypass tubing marks lined up with the ESP necks. Do not allow the bypass to slip.
16. Secure bypass with friction clamp.
17. Add additional bypass tubing joint and next ESP section.
18. Continue steps 13 to 15 until the last joint of bypass tubing and ESP section are assembled.
19. Lower Y-tool assembly onto the ESP and Bypass strings.
20. The space out should be such that the teleswivel nipple is within reach of the bypass tubing when the ESP discharge head is made up to the pump. (Figure 3)
21. If the teleswivel does not have sufficient travel the units must be disassembled realigned to ensure the space out is correct.

It can be seen from this procedure that an accurate space out must be conducted before the installation commences. The assembly must ensure the bypass and ESP remain vertically aligned during the installation process. During the installation process a friction clamp must be used to secure the bypass tubing string as each joint of bypass tubing is added. The friction clamp must be made up to a specified torque level to ensure the bypass tubing does not slip during assembly. The clamp must be removed after each make up to allow installation to continue. The teleswivel gives compensation for a degree of error in the space out or handling whilst installing, typically allowing an error of +/-7.5 inches. However the installation process is time consuming, adding significantly to the installation time of a standalone ESP. The larger the ESP assembly the more pronounced the time gain occurs.

If the bypass tubing is supported using a pump support sub the bypass tubing must be manufactured to the exact length of the ESP assembly. The pump support sub secures the bottom of the ESP to the bypass tubing string and therefore does not allow the bypass tubing string to be adjusted to compensate for the length of the ESP. (figure 5).

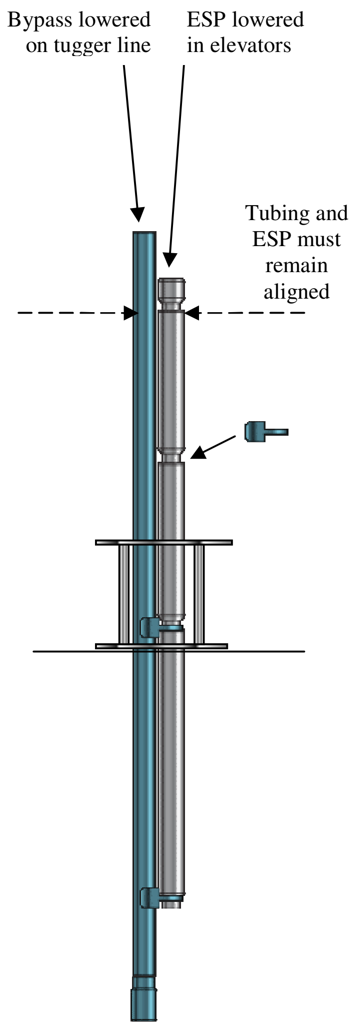

Figure 2 – Conventional Bypass System Alignment during installation

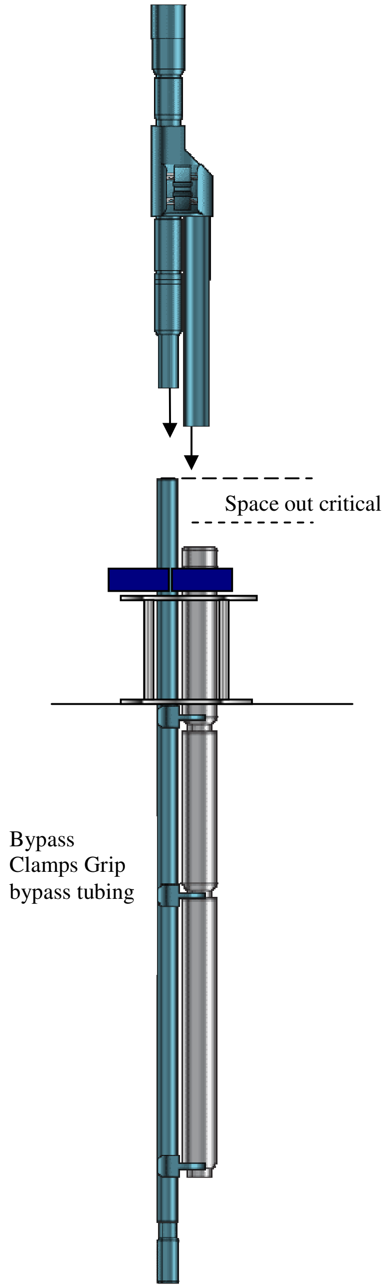

Figure 3 – Conventional Bypass System Space out criticality

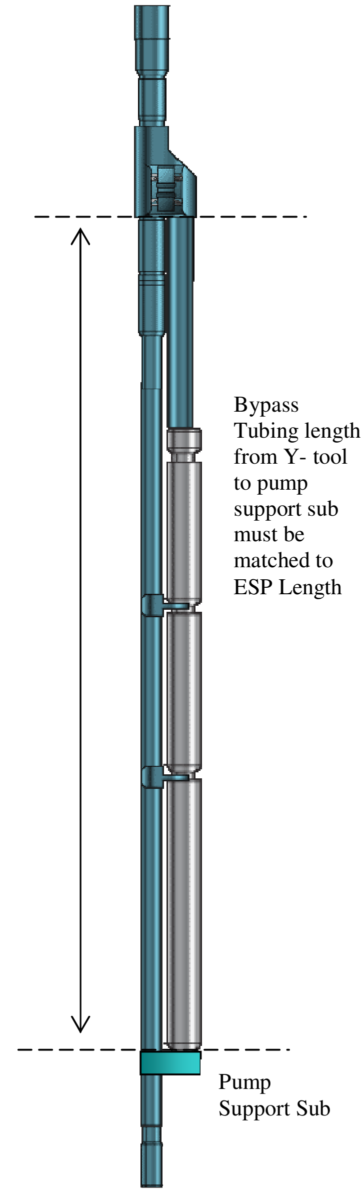

Figure 4 – Conventional Bypass System with Pump Support Sub.

If the derrick height is sufficient to allow the bypass and ESP to be picked up so that the lowest clamp can be installed the system can be built with a simple procedure below.

1. Assemble bypass tubing string and hang off on the worktable with a friction clamp.
2. Assemble the ESP assembly alongside the bypass tubing string.
3. Hang off ESP on the upper lifting clamp on the worktable.
4. Lower the Y-tool assembly (Figure 5 -part 1) onto upper ESP pump and make up flange of discharge head to the pump (Figure 5 -part 2)
5. Pick up weight of ESP and remove lifting clamp.
6. Lower ESP assembly with Y-tool Assembly and align to bypass string. (Figure 5 -part 3)
7. Make up teleswivel to bypass tubing.
8. Pick up entire assembly until the bottom of the ESP motor is at working height.
9. Make up lowest bypass clamp to ESP motor base.
10. Ensure assembly is orientated so as the Motor Lead can be attached from the spooler and sheave.
11. Run in Hole installing bypass clamps, control lines and motor lead extension cable.

Only the assembly of the bypass string, fitment of clamps, and make up of Y-tool assembly add additional time to the assembly of the ESP. If the bypass tubing uses flush joint connections a friction clamp will be required to support the tubing during assembly.

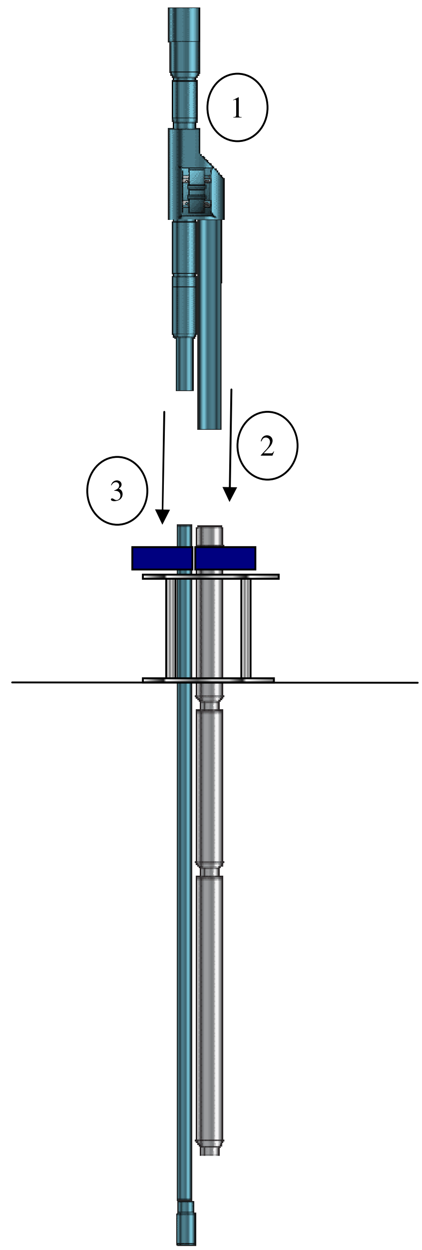

Figure 5 – Conventional Bypass System Method 2 – sufficient pick up height in derrick

Simplifying Installation – Bypass Saddle

The bypass saddle technology enables the bypass system and ESP to be built in one operation without the requirement for a friction clamp, space out operation or preset lengths of bypass tubing to match the ESP. The same procedure for assembling the bypass can be used regardless of derrick height.

The procedure to assemble a bypass system on the rig floor is simplified as follows:-

1. Make up bypass tubing tail pipe to Saddle Assembly.
2. Secure saddle on the worktable with a bypass support clamp under saddle.
3. Pick up ESP motor with spear assembly in the elevators and stab motor into the bypass saddle.
4. Fit the no-go sub to end of the spear.
5. Pick up the ESP motor in the elevators. This will lift the bypass tubing when the no-go engages with the saddle. (Figure 6)
6. Remove the bypass support clamp.
7. Run in hole and add ESP sections, bypass tubing and bypass clamps as required. (Figure 7). The weight of the bypass tubing is always supported on the saddle assembly.
8. Land off the upper ESP pump section on lifting clamp
9. Pick up Y-tool assembly and make up the discharge head to the upper ESP pump.
10. Pick up ESP with the Y-tool assembly and remove the lifting clamp.
11. Pick up until the top piece of bypass tubing is at working height
12. The top joint of bypass is fitted with a lift sub which will mate up directly to the Y-tool swivel nipple assembly.
13. Fit the bypass support clamp under the lift sub and land off the bypass string on the work table.
14. Continue to lower the ESP assembly. The bypass saddle and bypass clamps will allow the ESP to slide past the bypass tubing string until the Y-tool swivel can be made up to the bypass string.

The simplified procedure significantly reduces the installation time of the bypass and ESP assembly. The assembly of the bypass and ESP is not dependent on the available lifting height in the derrick and so the same procedure can be used for all installations.

The risk of equipment being dropped downhole is reduced as flush joint tubing is not required to be supported with a friction clamp during the assembly.

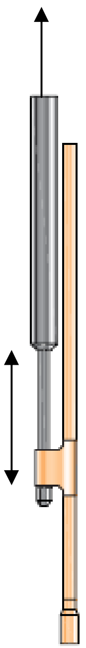

*Figure 6 –Bypass System with Saddle Assembly**

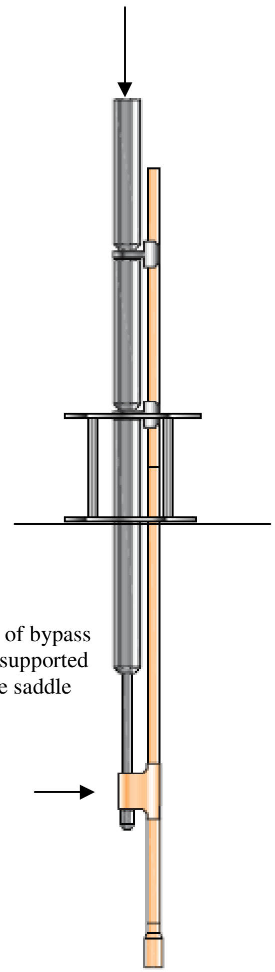

Figure 7–ESP and bypass built in parallel with weight supported on ESP

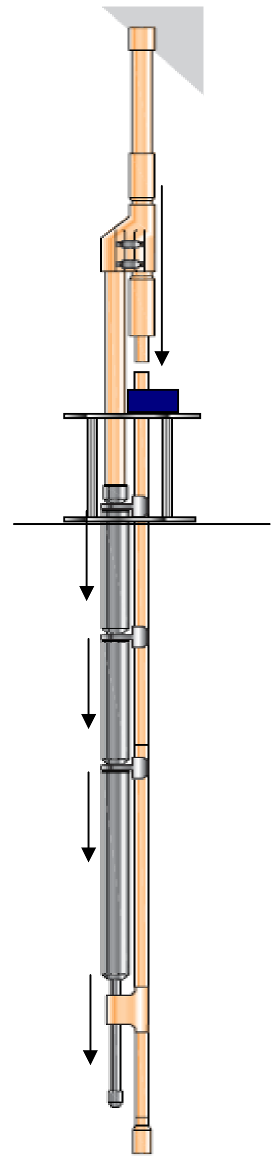

Figure 8–Bypass Slides through clamps & swivel landed on bypass tubing

Thermal Expansion of the ESP.

An ESP assembly will expand with increasing temperature. An ESP string can conceivably expand up to 1 inch in length during operation. In a regular ESP installation (without bypass system) the ESP is hanging from the tubing and therefore the consequences of this can be absorbed by the design of the ESP itself. However, if the ESP is clamped to a string of bypass tubing the ESP assembly may expand and contract at a different rate to the tubing it is clamped to.

When started, an ESP motor and pump will generate heat and expand more quickly than the bypass tubing. This will cause undue stresses on the bypass clamps and the ESP assembly. The problem may manifest itself as broken clamp bolts, or in extreme cases bending of the ESP assembly.

The change in length of a material due to thermal expansion in a unidirectional expansion is given by

$$dL = a(dT)L$$

dL = Change in Length

a =Thermal Expansion Coefficient of material

dT = change in temperature

L = Length of object

As an example :-

A steel object with a thermal expansion coefficient (a) = 6.3e-6 and length (L) = 30ft will expand 0.2268 of an inch with a 100F rise in temperature.

If the ends of this 30 foot long object are held rigid the object will eventually bow. (figure9). The bow can be calculated as follows.

Solving for r:-

$\sin \theta/2 = L/2r$ where $\theta = LE / r$ (radians)

$L/2 = r \sin ((LE/2)/r)$

$180 = r \sin (180.1134/r)$ therefore $r = 2930$

Solving for b: - $b = r - x$

$x = \sqrt{(2930^2 - 180^2)} = 2924.4658$

$b = 2930 – 2924.4658$

b = 5.543 inches of deflection

b = deflection
r = radius
L = length of object = (360)
LE = length of expanded object = 360.2268

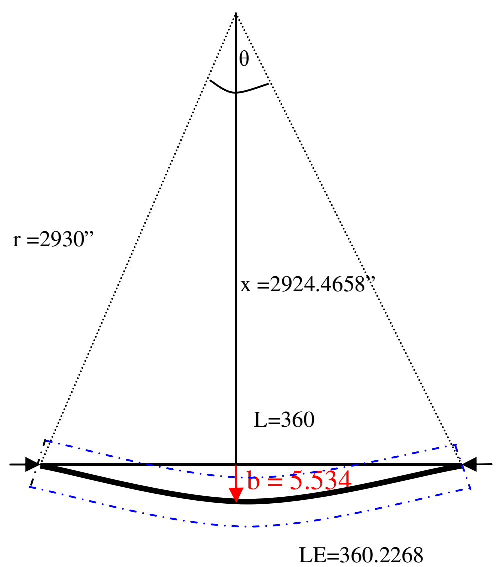

Figure 9– 5.5 inches of bend in a 360 inch long object expanding by .2268 of an inch

An ESP section clamped to bypass tubing will be unable to bend by this amount due to the inside diameter of the casing. The bypass tubing will be forced to stretch placing large forces on the clamps and ESP assembly.

The stresses placed on the ESP assembly are more pronounced with bypass systems where both ends of the ESP are fixed to the bypass tubing string – i.e. systems using pump support subs (fig 4).

This can be alleviated by allowing the clamps to slide along the bypass tubing. The ESP can expand and contract independently from the bypass tubing as the two strings are not bound together.

Findings and Conclusions.

The new technology bypass system with saddle has been deployed by many operators. Significant reduction in installation times have been demonstrated as follows.

With increase demand for rig time the time saved and reduction of risk of errors during assembly help to reduce cost and provide a more efficient operation.

Operator	Regular Bypass & ESP (Hours)	New Technology Bypass & ESP (Hours)	**Time Saved** (Hours)
KOC	12	5	**7**
GNPOC	12	5.5	**6.5**
Oxy	8	3.5	**4.5**
Perenco	17	9.5	**7.5**

Although difficult to quantify, the systems ability to let the ESP expand and contract freely will enhance runlife through reduction of stresses on the ESP assembly. The likelihood of damage to clamp bolts through thermal expansion is removed.