

Description

The present invention relates to an improved subsea wellhead in which either the production string or the production tree may be easily and quickly recovered from their subsea location and readily reinstalled without the excessive loss of downtime normally associated with such operations.

Prior to the present invention, the removal of either of the production tubing or the production tree from a subsea well could only be accomplished by utilizing the steps of their installation in the reverse order for recovery. This entails substantial equipment for the removal of the tree and for the removal of the tubing string. None of the known prior art allowed the easy removal of the production tree in any manner.

EP-A-0572732, published after the priority date of the present application, and constituting prior art in accordance with Article 54(3) EPC, describes an improved wellhead in which the production tubing and tubing hanger can be retrieved without pulling the production tree. This art, however, requires that the production tubing be pulled prior to pulling the tree. There is no suggested structure or steps by which the tree can be removed, without first removing the production tubing, other than by the extended procedure which reverses its installation process.

The present invention relates to an improved subsea wellhead in which the production string may be quickly and easily removed, or the production tree may be quickly and easily removed, each independent of the other. The structure includes the wellhead housing with the casing hangers supporting the casing strings landed in the housing, a tree connected to the upper end of the wellhead housing, an upper false tubing hanger landed in the tree and having communication with the production line extending radially out of the tree, a tubular member extending downwardly therefrom, an orienting lip extending downwardly therefrom and a sleeve extending downwardly around the exterior of the orienting lip and tubular member, and a lower tubing hanger landed within the inner casing hanger and having the production tubing string extending downwardly therefrom and an internal preparation for a sealing plug and any other downhole devices desired. With the two casing hangers, the production string can still be sealed with a plug when the upper hanger is removed and the tree is removed. In addition with this structure the complete production tubing string including both tubing hangers may be quickly and easily retrieved from the well and replaced therein.

An object of the present invention is to provide an improved subsea wellhead as defined by claim

1 in which either the production string or the production tree may be easily and quickly removed.

A further object is to provide an improved method as defined by claim 5 of retrieving a tree from a subsea well without having to remove the production tubing.

Still another object is to provide an improved method as defined by claim 8 of retrieving the production string and/or the production tubing from a subsea well quickly and easily with only a blowout preventer, and without having to remove the tree.

These and other objects and advantages are hereinafter set forth and explained with reference to the drawings wherein:

FIGURE 1 is a schematic illustration of the prior art subsea wellhead structure with the production tree installed thereon and the production string installed therein.

FIGURE 2 is a vertical sectional view of the wellhead housing with the improved production tree and production string installed therein.

FIGURE 3 is a series of vertical sectional views of the wellhead housing with a hanger cap installed therein above the production tubing and tubing hanger. FIGURE 3A is the upper portion of the structure, FIGURE 3B is the intermediate portion of the structure and FIGURE 3C is the lower portion of the structure.

FIGURE 4 is a sectional view of the wellhead with a wellhead seal cap installed.

As shown in FIGURE 1, the subsea wellhead of the prior art includes housing 10 having casing hanger 12 landed therein and supporting casing string 14 extending downwardly from hanger 12. Tree 16 is suitably connected to the upper end of housing 10 by remote operated connector 17 and production tubing hanger 18 is landed therein with production tubing 20 extending downwardly therefrom. Locating member 22 is supported within tree housing 10 and engages casing hanger 12 and has an upper helix surface 24 which coacts with lower helix surface 26 on tubular member 28 extending downward from tubing hanger 18 to ensure the proper orientation of tubing hanger 18 within tree 16 so that port 30 through the side of tubing hanger 18 registers with port 32 which extends through tree 16 and communicates with external production connection 34 which is under the control of valve 36. Isolation cap 38 is landed within tree 16, plug 40 is landed in hanger 18 immediately above port 30 and plug 42 is landed in isolation cap 38 so that production is directed out through ports 30 and 32 and through connection 34 and valve 36.

With the components positioned as shown in FIGURE 1, production through tubing string 20 is under the control of valve 36 and the annulus

pressure is under control of isolation cap 38 which is sealed within tree 16. In order to pull the production string, it is only necessary to lower and secure a suitable blowout preventer to the upper end of tree 16 and then remove isolation cap 38 and tubing hanger 18 with tubing string 20 secured thereto from the well. During these operations the well is under the control of the blowout preventer. Since the subsea apparatus shown in FIGURE 1 does not include a separate tubing hanger supported within the well at a point below the tree, the recovery of the tree from the subsea well is only possible with the extended and complicated procedures of the prior art which are necessary to maintain control of the well during these operations.

Wellhead housing 50, as shown in FIGURE 2, has casing hangers 52 and 53 landed therein with the casing strings 54 and 55 extending down into the well from the hangers 52 and 53. Lower tubing hanger 56 is landed within casing hanger 52 and supports tubing string 58 which extends downwardly from the lower end thereof.

Tree sub 60 is landed and secured by clamp 61 to the upper end of housing 50 and tree 62 is landed on and secured to the upper end of tree sub 60 by clamp 63. clamp 61 is a remotely operated clamp so that it may be released when tree 62 is to be removed. Upper false tubing hanger 64 is landed within tree 62 as shown and includes tubular member 66 threaded into its lower opening and sleeve 88 attached to the exterior of its lower end having orienting key 71 mounted to its exterior surface. Tubular member 66 extends downwardly and seals within lower tubing hanger 56. Tubular orienting member 72 is mounted within tree sub 60 and includes upper helix surface 74 which receives key 71 to cause the upper hanger 64 to rotate so that port 76 in upper hanger 64 registers with port 78 in tree 62 allowing production flow from tubing string 58 to flow therethrough into suitable production lines 80 with suitable valving (not shown). When ready for production, upper cap 82 is secured and sealed within the upper end of tree 62 and includes a central bore registering with the central bore of upper tubing hanger 64 and having a configuration to allow lower plug 84 to be seated and sealed within upper tubing hanger 64 and to allow upper plug 86 to be seated and sealed within the central bore of upper cap 82. Lower tubing hanger 56 includes optional electrical connector 89 for use in communicating with a downhole electrical device, such as a pressure transducer. A hydraulic control line coupling 92 is provided to allow communication to a downhole safety valve. Tubing hanger 56 also includes an orienting pin (not shown) located approximately 90° from control line coupling 92 and pointing vertically upward to engage the lower end of hanger cap 90 to

ensure proper axial alignment of the entire assembly when it is returned to the wellhead after having been removed.

When it is desired to recover the production tubing string 58, any suitable blowout preventer may be installed on the upper end of tree 62 to place the well under control and then upper cap 82 is released and recovered through the blowout preventer. With upper cap 82 removed a suitable tool is run to engage and recover upper tubing hanger 64 including tubular member 66 and sleeve 88 with orienting key 71 attached thereto. Thereafter, a tool is run into engagement with lower tubing hanger 56, which has tubing string 58 suspended therefrom, and it is recovered from the wellhead housing 50. With the production tubing and tubing hangers removed from the wellhead housing 50 any desired work or change in equipment may be performed in the well and then the production tubing and tubing hangers are again set in the wellhead housing 50.

In the event that it is desired that tree 62 be removed from the wellhead without removing the production tubing, a suitable blowout preventer is connected to the upper end of tree 62. With the blowout preventer in place, upper cap 82 is engaged and retrieved. Then upper tubing hanger 64 with upper tubular member 66, sleeve 88 and hanger cap 90 attached thereto, is engaged and retrieved. As shown in FIGURE 4, a suitable wellhead seal cap 190 is secured within lower tubing hanger 56 to control the production string and the casing annulus. If desired, a wireline plug may be seated within the wireline prep 91 in the production bore of tubing hanger 56. This seals the production bore and annulus. With the well under control, the blowout preventer can be removed and then tree 62 is removed. After all operations planned for the well while tree 62 is removed, tree 62 is returned and connected to the upper end of tree sub 60 and after the blowout preventer has been connected to the upper end of tree 62. The wellhead seal cap 190 is recovered and then the remainder of the production equipment is reinstalled.

In the event that both the tree 62 and the production tubing string 58 are to be retrieved, then it is suggested that the tubing string 58 should be recovered as set forth above and a suitable plug is set in the inner casing hanger to close the well and thereafter, the tree 62 and tree 60 can be released and retrieved by remotely releasing clamp 61 and recovering them to the surface.

It should be noted that tree sub 60 is used primarily only in subsea guidelineless completions where it is desirable to elevate tree 62 above the upwardly facing funnel typically installed about the wellhead housing 50 and thereby, gain clearance for the production flowlines. In a typical guideline completion, tree sub 60 and clamp 63 would not be



used. The lower end of tree 62 would be slightly longer and connected directly to the upper end of housing 50 by claim 61. Tubular member 66 and sleeve 88 would both be substantially shorter.

From the foregoing, it can be seen that the present invention provides an improved subsea wellhead in which either the production equipment within the well may be safely and quickly removed from within the tree or the production equipment may remain in the well bore and the tree retrieved from the wellhead housing. Maintenance to either the downhole production equipment or the seabed tree can be performed independently without the requirement to retrieve both.

Claims

1. A subsea wellhead completion system comprising
 - a wellhead housing having an internal bore,
 - a lower tubing hanger with a production tubing string extending downwardly therefrom and supported within said internal bore of the wellhead housing,
 - an upper false tubing hanger having a production bore therethrough,
 - said lower tubing hanger having a central production bore therethrough with a wireline plug prep therein for receiving a wireline plug to close the production bore below said upper tubing hanger,
 - a tree having a radial production port connecting to production lines and productions control means,
 - means for connecting said tree to said wellhead housing,
 - means connecting said production bores of said upper hanger and said lower hanger,
 - orienting means to orient said upper tubing hanger to its desired position within said tree to allow radial flow of production fluids from said production bore of said upper tubing hanger through said tree,
 - means in said upper tubing hanger above said radial port to receive an upper bore plug and a lower bore plug, and
 - means in said tree for receiving an upper cap.
2. A subsea wellhead according to claim 1 including
 - casing hangers supported within the internal bore of said wellhead housing, and
 - means on the interior of the inner casing hanger for supporting said lower tubing hanger.
3. A subsea wellhead according to claim 1 including
 - a radial port in said upper hanger,
 - a radial port in said tree,
 - said orienting means causing rotation of said upper tubing hanger within said tree as it is lowered therein to bring the radial port in the upper tubing hanger into registry with the radial port in said tree.
4. A subsea wellhead according to claim 1 wherein the production tree and the production tubing each may be removed individually without removal of the other.
5. The method of servicing a subsea well which has a wellhead housing, a tree secured to the upper end of the wellhead housing, a lower production tubing hanger landed within said wellhead housing, an upper false tubing hanger landed within said tree, and radial passage means extending through said upper tubing hanger and said tree which method includes the steps of
 - setting a blowout preventer on the upper end of the tree,
 - removing the upper tubing hanger from within the tree,
 - closing and sealing the production bore through the lower tubing hanger within said lower tubing hanger,
 - removing said blowout preventer from the tree, and
 - removing the tree from the wellhead housing.
6. The method according to claim 5 including the steps of
 - lowering and connecting the tree to the upper end of the wellhead housing,
 - lowering and connecting a blowout preventer to the upper end of the tree,
 - retrieving from the production bore the closing and seal element,
 - lowering and landing the upper hanger in the tree with the radial passage means of said upper hanger and said tree being in registry,
 - closing the production bore through said upper hanger above said radial passage means, and
 - retrieving said blowout preventer.
7. The method according to claim 6 wherein the blowout preventer used to maintain control of the well during the removal and resetting of the tree may be a wireline blowout preventer.



8. The method of servicing a subsea well which has a wellhead housing, a tree secured to the upper end of the wellhead housing, a lower production tubing hanger landed within said wellhead housing, an upper false tubing hanger landed within said tree, and radial passage means extending through said upper tubing hanger and said tree which method includes the steps of

setting a blowout preventer on the upper end of the tree,

removing the upper tubing hanger from within the tree, and

removing the lower tubing hanger and the tubing string from within the wellhead housing and retrieving from the subsea well.

9. The method according to claim 8 wherein said tree includes a top cap closing the upper end of its bore and including the step of removing the top cap from said tree.

10. The method according to claim 8 including the steps of

lowering and landing the lower tubing hanger with the production tubing extending downwardly therefrom into the interior of the wellhead housing,

lowering and landing the upper tubing hanger with the a means to connect the production bores of the upper and lower tubing hangers,

setting tubing plugs in the upper tubing hanger, and

lowering and setting a top cap on the upper end of the tree.

Patentansprüche

1. Unterwasserbohrlochkopf-Verrohrungssystem, gekennzeichnet durch ein Bohrlochkopfgehäuse mit einer Innenbohrung, eine untere Rohraufhängung mit einem Förderrohrstrang, der sich von dieser nach unten erstreckt und in der Innenbohrung des Bohrlochkopfgehäuses abgestützt wird, eine obere Hilfsrohraufhängung mit einer durchgehenden Förderbohrung, wobei die untere Rohraufhängung eine durchgehende, mittlere Förderbohrung mit einer darin befindlichen Drahtseil-Stopfenaufnahme zum Aufnehmen eines Drahtseil-Stopfens aufweist, um die Förderbohrung unterhalb der oberen Rohraufhängung zu verschließen, einen Aufsatz mit einer radialen Förderöffnung als Verbindung zu den Förderleitungen und

den Förder-Steuereinrichtungen, eine Einrichtung zum Verbinden des Aufsatzes mit dem Bohrlochkopfgehäuse, eine Einrichtung zum Verbinden der Förderbohrungen der oberen Aufhängung mit denen der unteren Aufhängung, eine Ausrichtungseinrichtung zur Ausrichtung der oberen Rohraufhängung in deren erforderliche Position innerhalb des Aufsatzes, um einen radialen Fluß von Förderfluid von der Förderbohrung der oberen Aufhängung durch den Aufsatz zu ermöglichen, eine Einrichtung in der oberen Rohraufhängung oberhalb der radialen Öffnung, um einen oberen und einen unteren Bohrstopfen aufzunehmen, und eine Einrichtung im Aufsatz zur Aufnahme einer oberen Kappe.

2. Unterwasserbohrlochkopf nach Anspruch 1, gekennzeichnet durch Futterrohraufhängungen, die in der Innenbohrung des Bohrlochkopfgehäuses abgestützt sind, und eine Einrichtung an der Innenseite der inneren Futterrohraufhängung zum Abstützen der unteren Rohraufhängung.

3. Unterwasserbohrlochkopf nach Anspruch 1, gekennzeichnet durch eine radiale Öffnung in der oberen Aufhängung, eine radiale Öffnung im Aufsatz, wobei die Ausrichtungseinrichtung, die die Drehung der oberen Rohraufhängung im Aufsatz bewirkt, wenn sie darin abgesenkt wird, die radiale Öffnung in der oberen Rohraufhängung mit der radialen Öffnung im Aufsatz ausfluchtet.

4. Unterwasserbohrlochkopf nach Anspruch 1, dadurch gekennzeichnet, daß der Förderaufsatz und die Förderverrohrung einzeln, ohne Entfernung der jeweils anderen Baugruppe, entfernt werden können.

5. Verfahren zur Wartung von Unterwasserbohrungen unter Verwendung eines Bohrlochkopfgehäuses, eines Aufsatzes, der am oberen Ende des Bohrlochkopfgehäuses befestigt ist, einer unteren Förderrohraufhängung, die im Bohrlochkopfgehäuse gelandet ist, einer oberen Hilfsrohraufhängung, die im Aufsatz gelandet ist, und einer radialen Durchgangseinrichtung, die sich durch die obere Rohraufhängung und den Aufsatz erstreckt, gekennzeichnet durch folgende Verfahrensschritte: Aufsetzen eines Bohrlochschiebers auf das



obere Ende des Aufsatzes,
Entfernung der oberen Rohraufhängung aus dem Inneren des Aufsatzes,
Verschließen und Abdichten der durch die untere Rohraufhängung führenden Förderbohrung innerhalb der unteren Rohraufhängung,
Entfernung des Bohrlochschiebers vom Aufsatz und Entfernung des Aufsatzes vom Bohrlochkopfgehäuse.

6. Verfahren nach Anspruch 5, **gekennzeichnet durch die Verfahrensschritte:**

Absenkung und Verbindung des Aufsatzes mit dem oberen Ende des Bohrlochkopfgehäuses,
Absenkung und Verbindung eines Bohrlochschiebers mit dem oberen Ende des Aufsatzes,

Rückholung des Verschluß- und Dichtungselementes aus der Förderbohrung,

Absenkung und Landung der oberen Aufhängung im Aufsatz unter Ausfluchtung der radialen Durchgangeinrichtung der oberen Aufhängung mit dem Aufsatz,

Verschließen der durch die obere Aufhängung hindurchgehenden Förderbohrung oberhalb der radialen Durchgangeinrichtung und Rückholung des Bohrlochschiebers.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet**, daß der Bohrlochschieber, der verwendet wird, um die Kontrolle über die Bohrung während der Entfernung und des Wiederaufsetzens des Aufsatzes aufrechtzuerhalten, ein Seilbahn-Bohrlochschieber sein kann.

8. Verfahren zur Wartung von Unterwasserbohrungen mit einem Bohrlochkopfgehäuse, einem Aufsatz, der mit dem oberen Ende des Bohrlochkopfgehäuses verbunden ist, einer unteren Förderrohraufhängung, die im Bohrlochkopfgehäuse gelandet ist, einer oberen Hilfsrohraufhängung, die im Aufsatz gelandet ist, und einer radialen Durchgangeinrichtung, die sich durch die obere Rohraufhängung und den Aufsatz erstreckt, **gekennzeichnet durch die Verfahrensschritte:**

Aufsetzen eines Bohrlochschiebers auf das obere Ende des Aufsatzes,

Entfernung der oberen Rohraufhängung aus dem Inneren des Aufsatzes und

Entfernung der unteren Rohraufhängung und des Rohrstranges aus dem Inneren des Bohrlochkopfgehäuses sowie Rückholung aus der Unterwasserbohrung.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet**, daß der Aufsatz eine Schutzkappe aufweist, die das obere Ende seiner Bohrung

verschließt, und daß es den Schritt des Entfernens der Schutzkappe vom Aufsatz umfaßt.

10. Verfahren nach Anspruch 8, **gekennzeichnet durch die Verfahrensschritte:**

Absenkung und Landung der unteren Rohraufhängung mit dem sich nach unten erstreckenden Förderrohrstrang im Inneren des Bohrlochkopfgehäuses,

Absenkung und Landung der oberen Rohraufhängung mit einer Einrichtung zur Verbindung der Förderbohrungen der oberen und der unteren Rohraufhängung,

Einsetzen von Rohrstopfen in die obere Rohraufhängung,

sowie Absenkung und Aufsetzen einer Schutzkappe auf das obere Ende des Aufsatzes.

Revendications

1. Système de complétion de tête de puits sous-marine comportant

un boîtier de tête de puits ayant un alésage intérieur,

un dispositif de suspension de tube inférieur ayant une ligne de tube de production s'étendant vers le bas à partir de celui-ci et supportée à l'intérieur dudit alésage intérieur du boîtier de la tête de puits,

un faux dispositif de suspension de tube supérieur ayant un alésage de production traversant celui-ci,

ledit dispositif de suspension de tube inférieur ayant un alésage de production central traversant celui-ci, un préparateur de bouchon de travail au câble étant situé dans celui-ci pour recevoir un bouchon de travail au câble destiné à fermer l'alésage de production situé en dessous dudit dispositif de suspension de tube supérieur,

un arbre ayant un orifice de production radial relié aux lignes de production et à des moyens de commande de production,

des moyens destinés à relier ledit arbre audit boîtier de la tête de puits,

des moyens reliant lesdits alésages de production dudit dispositif de suspension supérieur et dudit dispositif de suspension inférieur,

des moyens d'orientation destinés à orienter ledit dispositif de suspension de tube supérieur vers sa position voulue à l'intérieur dudit arbre pour permettre un écoulement radial des fluides de production à partir dudit alésage de production dudit dispositif de suspension de tube supérieur à travers ledit arbre,

des moyens situés dans ledit dispositif de suspension de tube supérieur situé au dessus dudit orifice radial pour recevoir un bouchon



- d'alésage supérieur et un bouchon d'alésage inférieur, et
des moyens situés dans ledit arbre pour recevoir un chapeau supérieur.
2. Tête de puits sous-marine selon la revendication 1 comportant des dispositifs de suspension de tubage supportés à l'intérieur de l'alésage intérieur dudit boîtier de la tête de puits, et
des moyens situés sur l'intérieur du dispositif de suspension de tubage intérieur destinés à supporter ledit dispositif de suspension de tube inférieur.
 3. Tête de puits sous-marine selon la revendication 1 comportant
un orifice radial situé dans ledit dispositif de suspension supérieur,
un orifice radial situé dans ledit arbre,
lesdits moyens d'orientation entraînant en rotation ledit dispositif de suspension de tube supérieur à l'intérieur dudit arbre lorsqu'ils sont abaissés à l'intérieur de celui-ci pour amener l'orifice radial situé dans le dispositif de tube supérieur en vis-à-vis de l'orifice radial situé dans ledit arbre.
 4. Tête de puits sous-marine selon la revendication 1, dans laquelle l'arbre de production et le tube de production peuvent être chacun enlevés de manière individuelle sans avoir à enlever l'autre.
 5. Procédé d'entretien d'un puits sous-marin qui a un boîtier de tête de puits, un arbre fixé à l'extrémité supérieure du boîtier de la tête de puits, un dispositif de suspension de tube de production inférieur en appui à l'intérieur dudit boîtier de la tête de puits, un faux dispositif de suspension de tube supérieur en appui à l'intérieur dudit arbre, des moyens formant passage radial s'étendant à travers ledit dispositif de suspension de tube supérieur et ledit arbre, lequel procédé comporte les étapes consistant à:
mettre en place un obturateur de puits sur l'extrémité supérieure de l'arbre,
enlever le dispositif de suspension de tube supérieur à partir de l'intérieur de l'arbre,
fermer et rendre étanche l'alésage de production traversant le dispositif de suspension de tube inférieur à l'intérieur dudit dispositif de tube inférieur,
enlever ledit obturateur de puits à partir de l'arbre, et
enlever l'arbre à partir du boîtier de la tête de puits.
 6. Procédé selon la revendication 5 comportant les étapes consistant à:
abaisser et relier l'arbre à l'extrémité supérieure du boîtier de la tête de puits,
abaisser et relier un obturateur de puits à l'extrémité supérieure de l'arbre,
récupérer à partir de l'alésage de production l'élément d'étanchéité et de fermeture,
abaisser et appuyer le dispositif de suspension supérieur dans l'arbre, les moyens formant passage radial dudit dispositif de suspension supérieur et dudit arbre étant en vis-à-vis,
fermer l'alésage de production traversant ledit dispositif de suspension supérieur au-dessus desdits moyens formant passage radial, et récupérer ledit obturateur de puits.
 7. Procédé selon la revendication 6, dans lequel l'obturateur de puits utilisé pour maintenir la commande du puits pendant l'enlèvement et la remise en place de l'arbre peut être un obturateur de puits de travail au câble.
 8. Procédé d'entretien d'un puits sous-marin qui a un boîtier de tête de puits, un arbre fixé à l'extrémité supérieure du boîtier de la tête de puits, un dispositif de suspension de tube de production inférieur en appui à l'intérieur dudit boîtier de la tête de puits, un faux dispositif de suspension de tube supérieur en appui à l'intérieur dudit arbre, et des moyens formant passage radial s'étendant à travers ledit dispositif de suspension de tube supérieur et ledit arbre, lequel procédé comporte les étapes consistant à:
agencer un obturateur de puits sur l'extrémité supérieure de l'arbre,
enlever le dispositif de suspension de tube supérieur à partir de l'intérieur de l'arbre, et
enlever le dispositif de suspension de tube inférieur et la ligne de tube à partir de l'intérieur du boîtier de la tête de puits et les récupérer à partir du puits sous-marin.
 9. Procédé selon la revendication 8 dans lequel ledit arbre comporte un chapeau supérieur fermant l'extrémité supérieure de son alésage et comportant l'étape consistant à:
enlever le chapeau supérieur dudit arbre.
 10. Procédé selon la revendication 8 comportant les étapes consistant à:
abaisser et appuyer le dispositif de suspension de tube inférieur, le tube de production s'étendant vers le bas à partir de celui-ci, à l'intérieur du boîtier de la tête de puits,
abaisser et appuyer le dispositif de sus-



pension de tube supérieur avec lesdits moyens pour relier les alésages de production des dispositifs de suspension de tube inférieur et supérieur,

mettre en place des bouchons de tube dans le dispositif de suspension de tube supérieur, et

abaisser et mettre en place un chapeau supérieur sur l'extrémité supérieure de l'arbre.

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