



CONSTRUCCIONES
METÁLICAS
DE OBTURACIÓN, S.L.

CMO



GESTION DE
LA CALIDAD
CERTIFICADA

QUALITY
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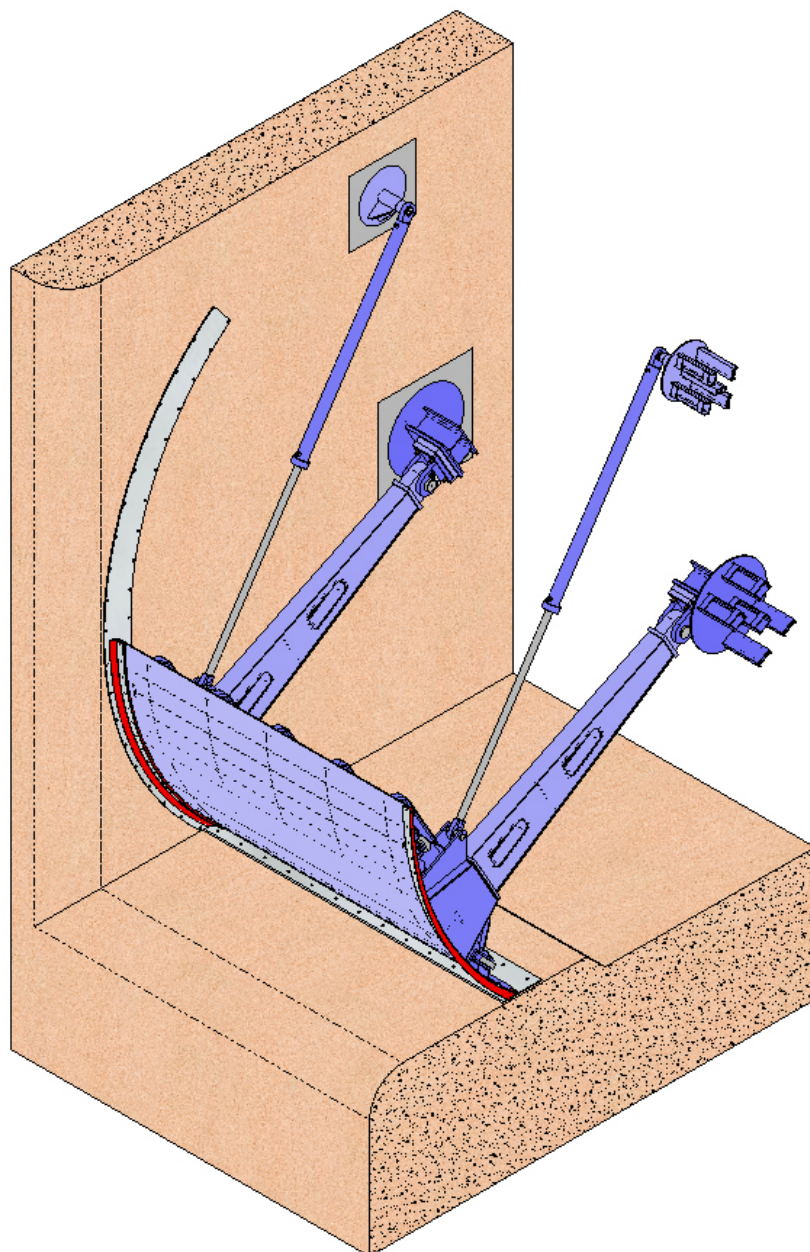
RADIAL PENSTOCK

CT SERIES

13/04/2015

INSTRUCTIONS AND MAINTENANCE MANUAL

SERIES: CT



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ASSEMBLY

THE CT PENSTOCK COMPLIES WITH THE FOLLOWING:

Machinery Directive: **DIR 2006/42/EC (MACHINERY)**.

HANDLING

Pay special attention to the following points when handling the equipment:

- **SAFETY WARNING:** Before handling the penstock, check that the crane to be used is capable of bearing its weight.
- Do not lift the penstock or hold it by the actuator. Lifting the penstock by the actuator can lead to operating problems as it is not designed to withstand the penstock's weight.
- When lifting the penstock, take care not to damage the sealing gaskets, as this may lead to leakage during the operation of the penstock.
- To prevent damage, especially to the anti-corrosive protection, it is recommended to use soft straps to lift the **CMO "Taintor"** penstocks.
- If the equipment is packed in wooden boxes, these must be provided with clearly marked holding areas where the slings will be placed when securing them. In the event of two or more penstocks being packed together, separation and securing elements must be provided between them to prevent possible movements, knocks and friction during transport. When storing two or more penstocks in the same box you must ensure they are correctly supported to prevent loss of shape. In the case of dispatches by sea we recommend the use of vacuum bags inside the wooden boxes to protect the equipment from contact with sea water.
- Pay special attention to maintaining the correct levelling of the penstocks during loading and unloading as well as during transport to prevent loss of shape in the equipment. For this purpose we recommend the use of mounts or stands.



INSTALLATION

In order to avoid personal injury and other types of damage (to the facilities, the penstock, etc.), we recommend following these instructions:

- The staff responsible for the installation or operation of the equipment must be qualified and trained.
- Use suitable Personal Protective Equipment (PPE) (gloves, safety boots, goggles, etc.).
- Shut off all lines which affect the penstock and put up a warning sign to inform about the work being carried out.
- Completely isolate the penstock from the whole process. Empty the duct or channel.
- Drain all the fluid from the duct or channel through the penstock.
- Use non-electric hand tools during installation and maintenance, in accordance with **EN13463-1 (15)**.



Before installation, inspect the penstock to ensure no damage has occurred during transport or storage.



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Ensure that the watertight integrity seals are clean and in a good condition. Check that the stainless steel surfaces where penstock sealing will take place are clean and smooth.

Inspect the channel or duct intended for installation of the penstock, making sure it is clean and flat.

Two different groups are differentiated within the CT-s penstocks, 3-side sealing and 4-side sealing:

- The **3-side seal** has seals on both sides and base. These are designed for installation in dam spillways or channels. They are used for water level control; with this design the fluid can overflow above the stopboard.
- The **4-side seal** has seals on both sides, base and lintel. These are designed for installation in water connections and bottom outlets. They are used as a regulation element.

ASPECTS TO BE CONSIDERED DURING ASSEMBLY

As mentioned, two main groups can be differentiated within CT radial penstocks, namely 3-side seal and 4-side seal. Although their assembly is very similar, there are small differences, and for this reason we will describe two differentiated assembly processes.

Assembly of penstocks with 3-side seals

As mentioned throughout these manuals, the 3-side sealing penstocks are installed in channels or spillways.

Since the CT penstocks transmit the entire hydraulic thrust through the turn points, it is very important to correctly secure their mounts to the civil engineering work. This can be guaranteed by choosing to embed the bases of the turning point in the concrete.

The steps below must be followed in order to mount this type of penstocks:

- The first step is to envisage housings in the civil engineering work in order to embed the bases of the turning points and cylinder fastening. It is important to leave protruding bars in these gaps, in order to weld them to the profiles of the bases, joined to the civil engineering reinforcement. The dimensions of the housings and their location will be carried out in accordance with the plans supplied by CMO.
- It is very important that the walls and base of the channel where the penstock is to be located are completely flat and level.
- Inspect to ensure the housings for the bases are sufficient and clean.

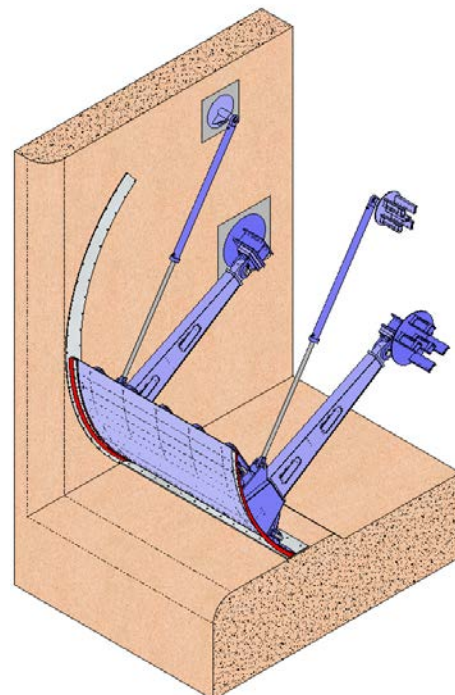
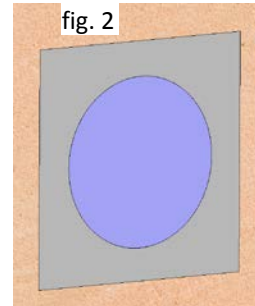


fig. 1

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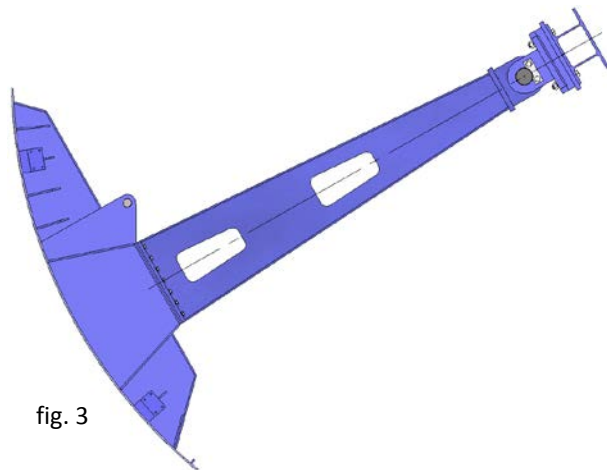
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- Proceed to position the bases of the turning points and the cylinder fastenings in the housings. Align them and ensure that the flat surface of the base is level with the channel walls. Once correctly in place, weld the protruding bars to the profiles of these bases, joining to the civil engineering work reinforcement.
- Carry out the second concreting. This operation consists of filling in the gaps of the housings, ensuring there is no protrusion in the channel (fig. 2).



- Once the faces of the turning points and the cylinder fastenings are assembled, position the sealing strips on the civil engineering work. In this type of penstock, the sealing strips also work as rolling strips. It is very important to position them correctly, respecting the levels shown in the general diagram and aligning them radially relative to the turning point, since they have to coincide with the sealing gaskets and the side guide wheels with the penstock both open and closed. First they must be positioned provisionally until the stopboard has been used to check they are correctly positioned, proceeding with definitive fastening once the check is complete.

- Once all the civil engineering work elements are in place, place the stopboard in its position. In order to carry out this operation, the arms are bolted to the stopboard and the turning points mounted on them.

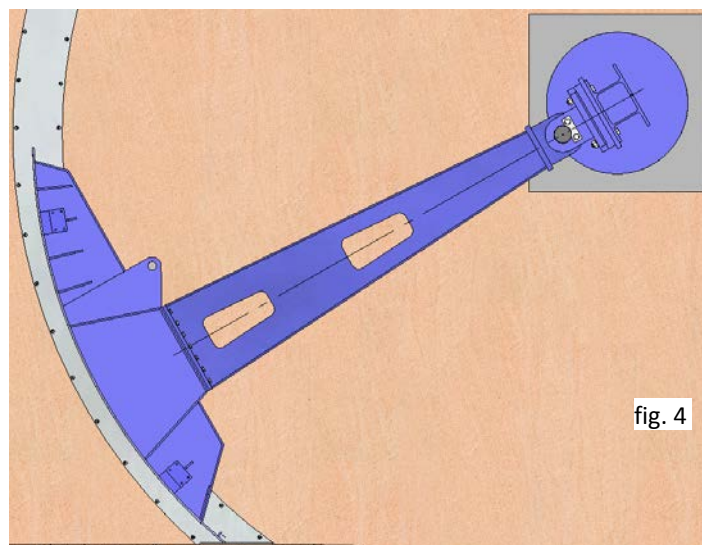


- When the penstock is completely closed, the turning points must be perfectly aligned with the axis of the arms, for which reason it is recommended to secure them specifically in this position in order to facilitate the assembly process. The turning points will be mounted with the brackets bolted down (fig. 3).

- Position provisional chocks on the sides of the stopboard in order to ensure that it is correctly aligned relative to the channel.

Once the stopboard unit has been mounted with the elements detailed above, proceed to position it in its location.

- After positioning the stopboard in closed position, bypass the brackets on the bases of the turning point embedded in the side walls (fig. 4).





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- Mount the hydraulic cylinders on the stopboard and spot weld their fastenings, aligned on the bases embedded in the channel walls.

- Release the swivel point fastenings.

- Before making the connections of the hydraulic cylinder, use a crane to carry out a penstock opening and closing test. This test can be used to ensure that the stopboard is correctly aligned relative to the channel and the closing and rolling strips have been positioned correctly in the stopboard run. It can also be used to check the correct positioning of the hydraulic cylinders (fig. 5).

- Once it has been checked that all the elements are correctly in place, proceed with definitive welding of the brackets of the turning points and cylinder fastenings.

- Continue to definitively secure the closing and rolling strips. These strips must be properly embedded in the concrete or bolted on the walls and base of the channel.

- A series of housings for these strips must be envisaged in the civil engineering work in order to embed them in the concrete, as with the turning point bases. The assembly process for these is identical to the one for the bases. Before laying the second layer of concrete, ensure that the flat surface of the strips is level with the walls of the channel and the base.
- If housing has not been envisaged for assembly, they can be bolted directly on the base and walls of the channel. It is very important that they are completely smooth, otherwise the strips may become deformed when tightening the anchors, thus preventing the required watertight integrity. When mounting bolted strips, apply beads of SIKAFLEX-11FC of between 2 and 5 millimetres on the surface where the civil engineering work will be supported, thus avoiding any leaks between it and the strips.

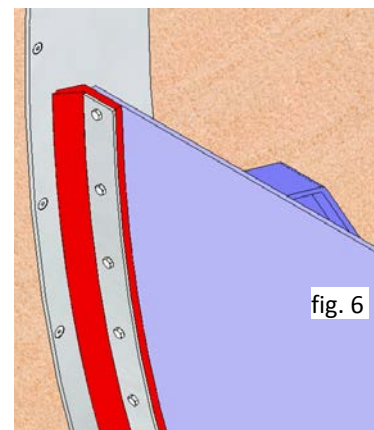
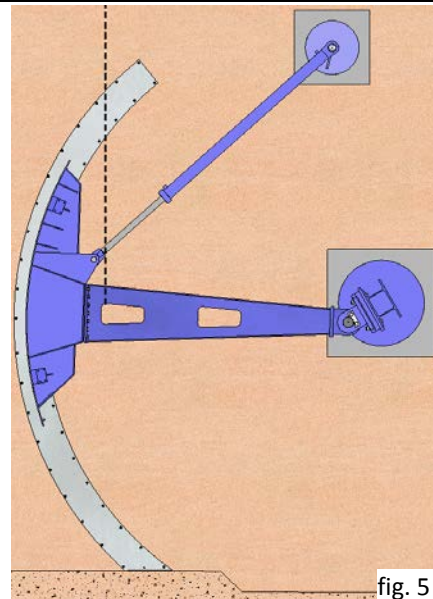
- Remove the chocks positioned provisionally on the stopboard in order to check alignment relative to the channel and mount the side guide wheels. When bolting these side guide wheels, they can be adjusted to the rolling strips by inserting intermediate chocks of different thicknesses.

- Continue to mount the seal system on the stopboard. Position the side watertight seals on the stopboard and secure them with the side seal flanges, bolting them down (fig. 6).

- Position the lower watertight integrity seal and secure it with the lower seal flange, bolting it down.

- Impregnating the watertight seals with petroleum jelly is recommended in order to lubricate them and improve their movement on the closing strips.

- Make the hydraulic installation, connecting the drive cylinders to the oil-hydraulic unit.





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- Check the correct operation of all elements which make up the **CT** penstock, carrying out opening and closing operations whilst empty using the hydraulic cylinders. These operations are also used to regulate the limit switches, positioners, etc. (fig. 7).
- Close the penstock and carry out the hydrostatic tests.

Note: At the end of the assembly, small misalignments may be observed in the penstock; these can be corrected using chocks of different thicknesses which can be inserted or removed between the turn points and the brackets.

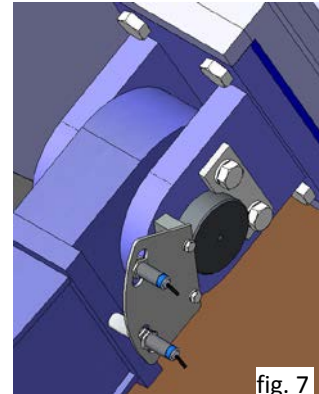


fig. 7

Assembly of penstocks with 4-side seals

As mentioned throughout these manuals, the 4-side sealing penstocks are installed in water connection points or dam bottom outlets.

The peculiarity of this type of penstock is that the sealing gaskets are secured to the civil engineering work. To this end, a type of metal mouth is mounted in concrete at the end of the duct, which the seals system is secured to using stainless steel flanges.

Since the **CT** penstocks transmit the entire hydraulic thrust through the turn points, it is very important to correctly secure their mounts to the civil engineering work. This can be guaranteed by choosing to embed the base of the turning point in the concrete.

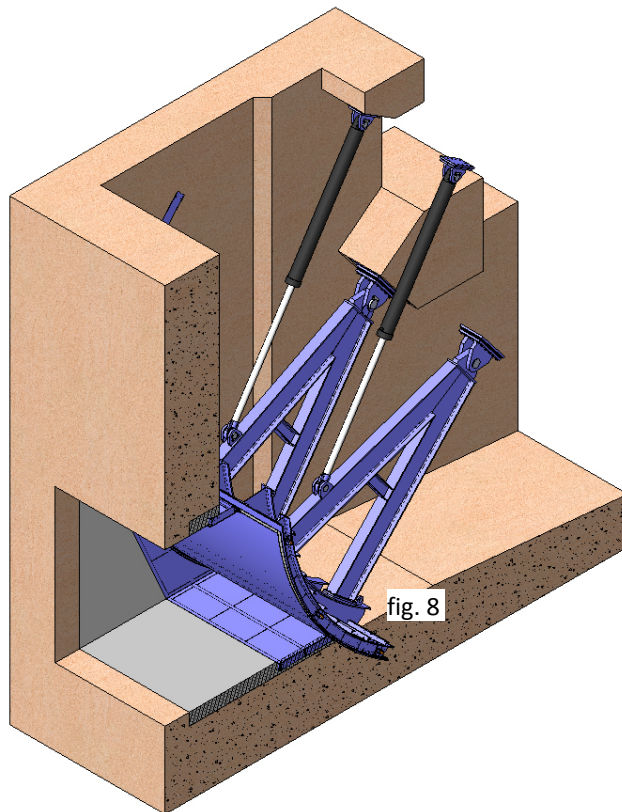


fig. 8

The steps below must be followed in order to mount this type of penstocks:

- Sufficient space must be left in the final section of the duct in order to mount the metal mouth, and it is important to leave a series of protruding bars in order to weld the mouth and join it to the duct reinforcement. The space required for the mouth is shown in the diagrams supplied by **CMO**.
- It is also necessary to envisage housings in the civil engineering work in order to embed the bases of the turning points and cylinder fastening. It is important to leave protruding bars in these gaps, in order to weld them to the profiles of the bases, joined to the reinforcement. The dimensions of the housings and their location will be carried out in accordance with the plans supplied by **CMO**.
- It is very important that the walls of the channel where the penstock is to be located are completely flat and level.



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- Inspect the space for the mouth and the housings to ensure the bases are sufficient and clean.

- Start by positioning the metal mouth at the end of the duct. Once correctly in place, weld the protruding bars to the mouth reinforcements to join to the duct reinforcement.

- Finish the mouth assembly process by carrying out the second concreting. This operation consists of filling in the gaps between the duct and the mouth, ensuring there is no protrusion in the duct (fig. 9).

- Continue to position the bases of the turning points and the cylinder fastenings in the housings. Position them on the base of the mouth in accordance with the measurements shown in the diagrams, and ensure that the flat surface of the base is level with the civil engineering work. Once correctly in place, weld the protruding bars to the profiles of these bases, joining to the civil engineering work reinforcement.

- Once the mouth and the bases of the turning points and the cylinder fastenings are assembled, position the rolling strips on the civil engineering work (fig. 10). It is very important to position them correctly, respecting the levels shown in the general diagram and aligning them radially relative to the turning point, since they have to coincide with the side guide wheels with the penstock both open and closed. First they must be positioned provisionally until the stopboard has been used to check they are correctly positioned, proceeding with definitive fastening once the check is complete.

- Once all the civil engineering work elements are in place, place the stopboard in its position. In order to carry out this operation, the arms are bolted to the stopboard and the turning points mounted on them.

- When the penstock is completely closed, the turning points must be perfectly aligned with the axis of the arms, for which reason it is recommended to secure them specifically in this position in order to facilitate the assembly process. The turning points will be mounted with the brackets bolted down. (fig. 3)

- Position provisional chocks on the sides of the stopboard in order to ensure that it is correctly aligned relative to the civil engineering walls.

- Once the stopboard unit has been mounted with the elements detailed above, proceed to position it in its location.

- To correctly position the stopboard on site, insert provisional chocks on the face of the stopboard and support the unit on the concreted mouth (fig. 11). The dimension of these will chocks will be defined in the detailed dimensions in the diagram supplied by CMO.

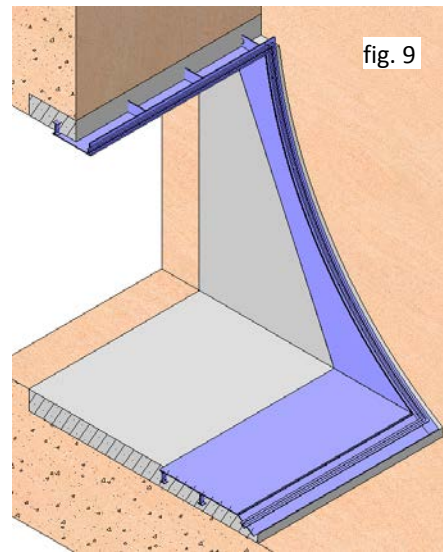


fig. 9

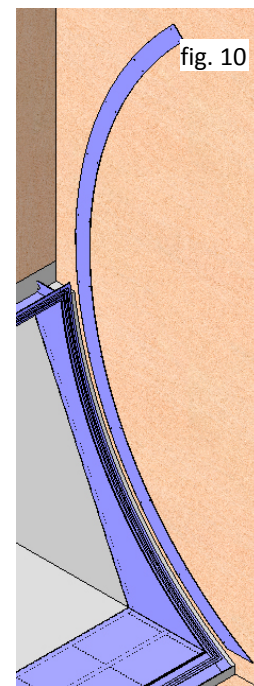


fig. 10

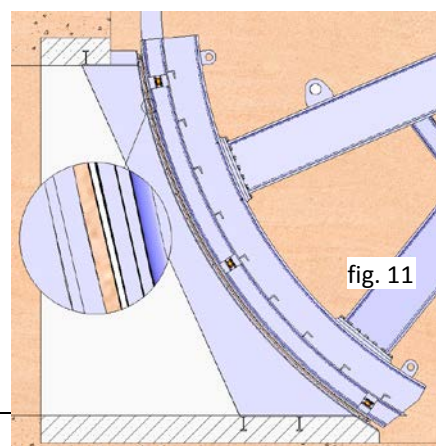


fig. 11



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- After positioning the stopboard in closed position, spot-weld the brackets on the bases of the turning point embedded in the side walls.
- Mount the hydraulic cylinders on the stopboard, extend the spindles to the maximum point and spot weld the fastenings of the cylinders on the bases embedded in the civil engineering work (fig. 12).
- Release the swivel point fastenings.
- Before making the connections of the hydraulic cylinder, use a crane to carry out a penstock opening and closing test. This test can be used to ensure that the stopboard is correctly aligned relative to the channel and the closing and rolling strips have been positioned correctly in the stopboard run.
- Once it has been checked that all the elements are correctly in place, proceed with definitive welding of the brackets of the turning points and cylinder fastenings.
- Continue to definitively secure the rolling strips. These strips must be properly embedded in the concrete or bolted on the walls of the channel.

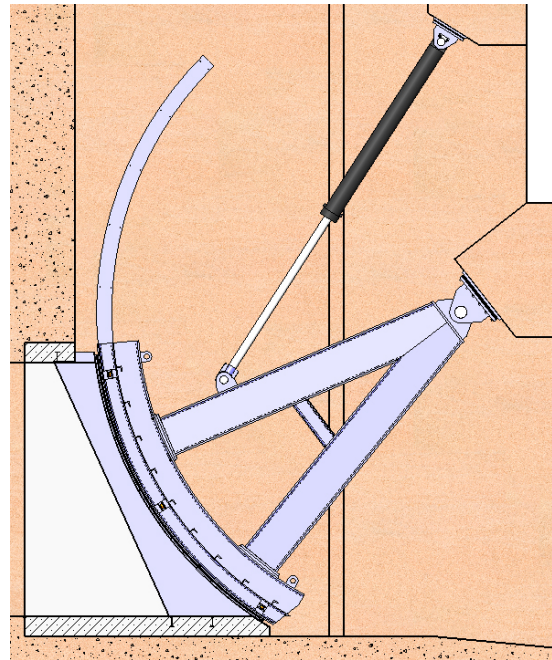


fig. 12

- A series of housings for these strips must be envisaged in the civil engineering work in order to embed them in the concrete, as with the turning point bases. The assembly profig. 13 these is identical to the one for the bases. Before laying the second layer of concrete, ensure that the flat surface of the strips is level with the walls of the channel.
- If housing has not been envisaged for assembly, they can be bolted directly on walls of the channel. It is very important that they are completely smooth, otherwise the strips may become deformed when tightening the anchors.
- Remove the chocks positioned provisionally on the stopboard in order to check alignment relative to the channel and mount the side guide wheels (fig. 13). When bolting these side guide wheels, they can be adjusted to the rolling strips by inserting intermediate chocks of different thicknesses.
- Remove the provisional chocks from the stopboard.

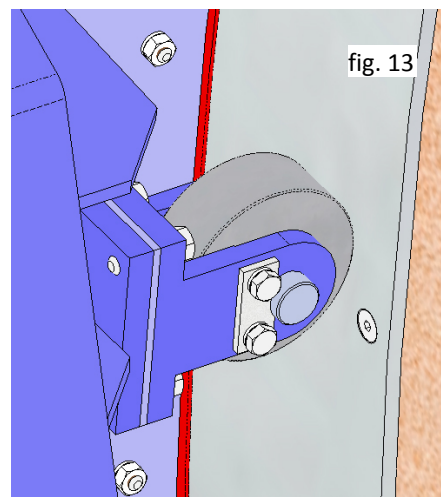


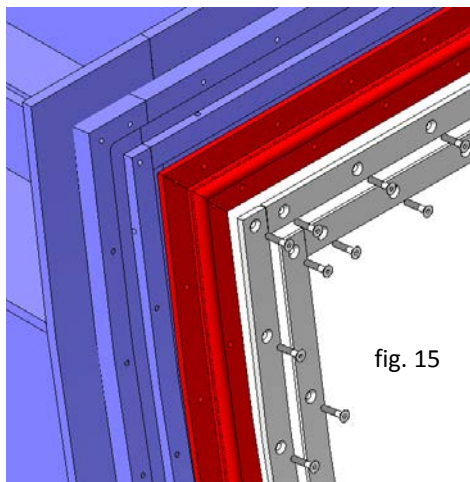
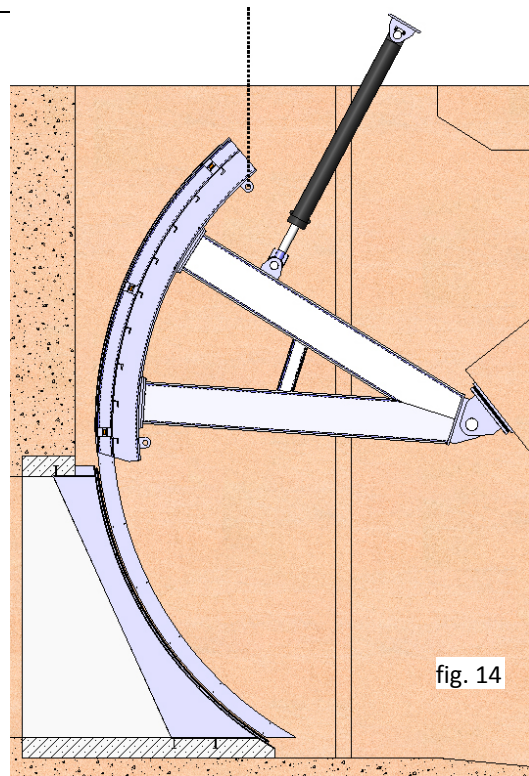
fig. 13



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- Dismount the hydraulic cylinder attachment to the civil engineering work and, with the help of a crane, raise the stopboard enough as to be able to mount the upper seal on the mouth (fig. 14).
- Mount the entire seals system on the concreted mouth in the civil engineering work. Position the watertight gaskets and secure them with the seal flanges, bolting them down (fig. 15).
- Check that the joints between side seals and the top and bottom are correct.
- Impregnating the watertight seals with petroleum jelly is recommended in order to lubricate them and improve their movement on the closing strips.
- Position the stopboard in closed position and reassemble the fastening of the hydraulic cylinders to the civil engineering work (fig. 12).
- Make the hydraulic installation, connecting the drive cylinders to the oil-hydraulic unit.
- Check the correct operation of all elements which make up the **CT** penstock, carrying out opening and closing operations whilst empty using the hydraulic cylinders. These operations are also used to regulate the limit switches, positioners, etc. (fig. 7).



- Close the penstock and carry out the hydrostatic tests.

Note: At the end of the assembly, small misalignments may be observed in the penstock; these can be corrected using chocks of different thicknesses which can be inserted or removed between the turn points and the brackets.

In all cases, for both 3-side and 4-side penstocks, the following points must be taken into account after the assembly process:

- The equipment must be firmly secured to the civil engineering work.
- As regards scaffolding, ladders and other auxiliary elements to be used during assembly, follow the safety recommendations indicated in this dossier.
- Once the equipment has been assembled, ensure that there are no elements which impede the movement of the stopboard.
- Make the relevant connections (electric, hydraulic, etc) in the equipment's actuator system following the instructions and cabling diagrams supplied with it.
- The assembly of the equipment must be coordinated with the site's control and safety staff and no modifications are permitted in the equipment's external indication elements (limit switches, detectors, positioners, etc.).
- Follow the safety recommendations indicated in this dossier when operating the equipment.

ACTUATOR

The most common drive system for these penstocks is the oil-hydraulic system. This type of drive comprises double acting hydraulic cylinder(s) and an oil-hydraulic unit. Depending on the dimensions of the penstock and of the water load to be withstood, two cylinders or a single cylinder may be required (one on each side). Whenever the penstock has two cylinders, the hydraulic cylinders will be connected so the same oil pressure is injected in both cylinders, meaning both cylinders apply the same force.

These hydraulic cylinders are fitted with front and rear hinges, which include maintenance-free spherical socket joints. These socket joints guarantee optimal fastening of the cylinder both with the penstock and with the fastening to the civil engineering work.

Although the oil-hydraulic system is the most widely used, there is also the possibility of using other types of drive. For example, another system could be by way of a geared motor. There are several methods to transmit the movement generated by this type of drive to the penstock: by pinion and chain, drum and cable, pinion and rack, etc. In all of them, whenever there are several pulling points on the penstock, these are joined mechanically in order to ensure that the pulling forces on the penstock are balanced.

MAINTENANCE

CMO will not be liable if the penstocks suffer any damage due to improper handling or without proper authorisation. The penstocks must not be modified except under express authorisation from CMO.

The following instructions should be followed in order to avoid personal injury or material damage when carrying out maintenance tasks:

- The staff responsible for the maintenance or operation of the equipment must be qualified and trained.
- Use suitable Personal Protective Equipment (PPE) (gloves, safety boots, goggles, etc.).
- Shut off all lines which affect the penstock and put up a warning sign to inform about the work being carried out.
- Completely isolate the penstock from the whole process. Empty the duct or channel.
- Drain all the fluid from the duct or channel through the penstock.
- Use non-electrical hand tools during maintenance, in accordance with **EN13463-1(15)**.



The only maintenance required in this type of penstock is to change the rubber seals. It is recommended to check every 6 months, however their working life will depend on the working conditions of the penstock, such as: pressure, temperature, number of operations, type of fluid and others. The attachment flanges to secure the rubber seals and the bolts used to fasten it are stainless steel, meaning both elements can be reused several times.

Regular cleaning of the penstock to prevent the build-up of residue.

Avoid re-painting the products supplied.



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IMPORTANT SAFETY ASPECTS

- In order to work in ideal safety conditions, both the electrical and magnetic elements must be idle. The electrical control cabinets must also be out of service. The maintenance staff must be up to date with the safety regulations and work can only start under orders from the site's safety staff.
- The safety areas must be clearly marked, avoiding the use of auxiliary equipment (ladders, scaffolding, etc.) in arms or moving parts, in order to produce the movement of the stopboard.
- In equipment fitted with an electrical actuator, it is recommended to disconnect it from the mains in order to access the moving parts without any risk.
- Due to its great importance, you must check that the penstock has no load before disassembling the actuator system.

Taking into account the recommendations indicated, the maintenance operations recommended for this type of equipment are shown below:

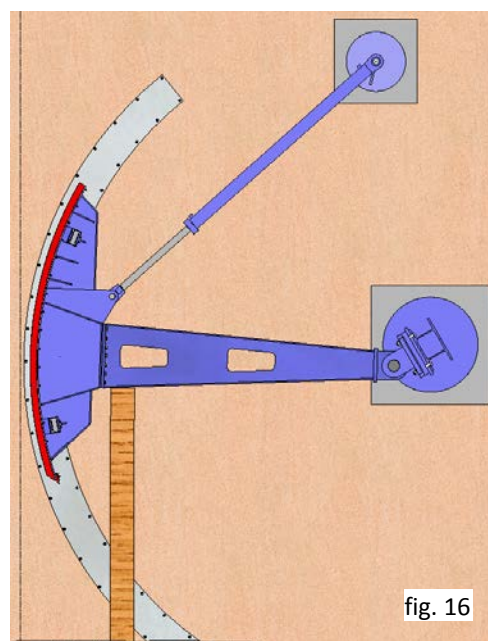
REPLACING THE GASKET

As mentioned several times above, two main groups can be differentiated within **CT** radial penstocks, namely 3-side seal and 4-side seal. The main difference between these is that in one of them the seal system is secured to the stopboard, whilst in the other it is secured to the civil engineering work. For this reason, the procedure to replace the seals is different, which is why two different processes are described.

Whatever the type of penstock, replacing the watertight integrity seals must be carried out without any fluid in the channel or duct.

Replacing seals of penstocks with 3-side seals

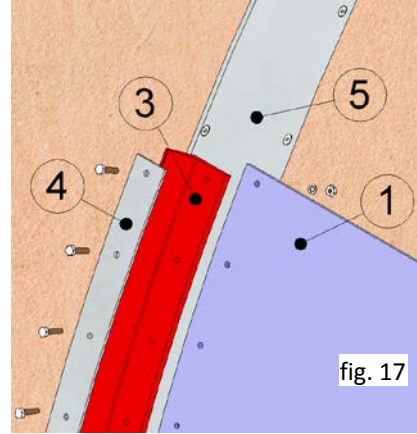
1. Make sure there is absolutely no pressure and fluid in the channel.
2. Position the penstock half-open and secure the stopboard in this position, e.g. using timber battens, slings, etc. (fig. 16).
3. Disconnect the oil-hydraulic unit from the power supply.
4. Release and extract the bolts which secure the flanges and the seals with the stopboard.
5. Remove the flanges and finally the deteriorated seal.
6. Clean the watertight seal housing.
7. Position the new seals impregnated with petroleum jelly on the stopboard, with the same dimensions as the ones removed.



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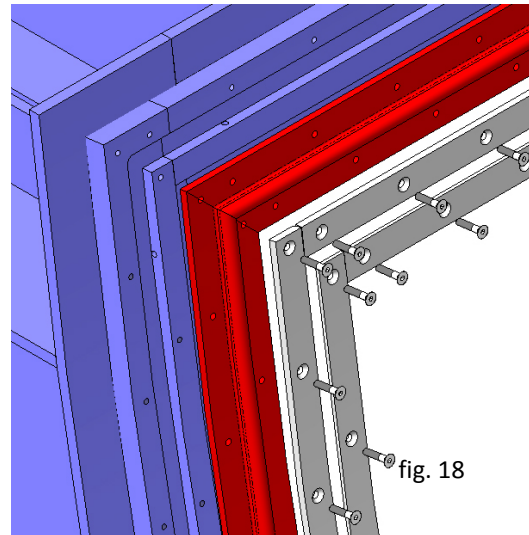
8. Reassembly flanges, securing the seal. It is important that the seals protrude from the stopboard the same distance as they protruded previously, in order to achieve the required watertight integrity.
9. Check that both the seals and the flanges are correctly mounted and bolt them down.
10. Connect the oil-hydraulic unit to the power supply.
11. Open the penstock a little further in order to remove the means used to secure the stopboard when replacing the seal.
12. Before starting up the installation, carry out several operations to open and close the penstock while empty, in order to verify that the seals close correctly.
13. Apply fluid load to the penstock and check the required watertight integrity.



Note: The numbers in brackets refer to fig. 19.

Replacing seals of penstocks with 4-side seals


1. Make sure there is absolutely no pressure or fluid in the duct.
2. Position the penstock in completely open position and secure the stopboard using slings with the help of a crane.
3. Disconnect the oil-hydraulic unit from the power supply.
4. Dismount the hydraulic cylinder attachment to the civil engineering work.
5. With the help of the crane, raise the stopboard enough as to be able to remove the upper mouth seal (fig. 14).
6. Secure the stopboard in this position, for example using timber battens.
7. Release and extract the bolts which secure the flanges and the seals to the mouth.
8. Remove the flanges and finally the deteriorated seals.
9. Clean the watertight seal housing.
10. Position the new seals on the mouth, with the same dimensions as the ones removed.
11. Join the corners after mitering and applying adhesive to cure.
12. Impregnate the seal joints with petroleum jelly.
13. Return the flanges, securing the seals.
14. Check that both the seals and the flanges are correctly mounted and bolt them down.
15. With the help of the crane, open the penstock a little further in order to remove the means used to secure the stopboard when replacing the seal.
16. Bring the stopboard down until the hydraulic cylinders can be mounted in the civil engineering work fastenings.



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17. Connect the oil-hydraulic unit to the power supply.
18. Before starting up the installation, carry out several operations to open and close the penstock while empty, in order to verify that the seals close correctly.
19. Apply fluid load to the penstock and check the required watertight integrity.

 **Note:** Applying petroleum jelly on the seals is recommended when replacing the watertight integrity seals, in order to lubricate them and improve movement on the closing strips, thus facilitating the correct operation of the penstock (do not use oil or grease); table 1 below shows details of the petroleum jelly used by CMO:

WHITE PETROLEUM JELLY		
Saybolt colour	ASTM D-156	15
Melting Point (°C)	ASTM D-127	60
Viscosity at 100°C	ASTM D-445	5
Penetration 25°C mm./ 10	ASTM D-937	165
Silicone content	None	
Pharmacopea BP	OK	

Table 1

STORAGE

To ensure the penstock is in optimum conditions of use after long periods of storage, we recommend storing it in a well-ventilated place at temperatures below 30°C.

It is not advisable, but, if stored outside, the penstock must be covered to protect it from heat and direct sunlight, with good ventilation to prevent humidity. The following aspects must be considered for storage purposes:

- The storage place must be dry and undercover.
- It is not recommended to store the equipment outdoors with direct exposure to adverse weather conditions, such as rain, wind, etc. Even when the equipment is packaged.
- This recommendation is even more important in areas with high humidity and saline environments. Wind can carry dust and particles which can come into contact with the penstock's moving parts and this can lead to operating difficulties. The actuator system can also be damaged due to the introduction of particles in the different elements.
- The equipment must be stored on a flat surface to avoid loss of shape.
- If the equipment is stored without suitable packing it is important to keep the penstock's moving parts greased, for this reason it is recommended to carry out regular checks and lubrication.
- Likewise, if there are any machined surfaces without surface protection, it is important for some form of protection to be applied to prevent the appearance of corrosion.



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COMPONENTS LIST

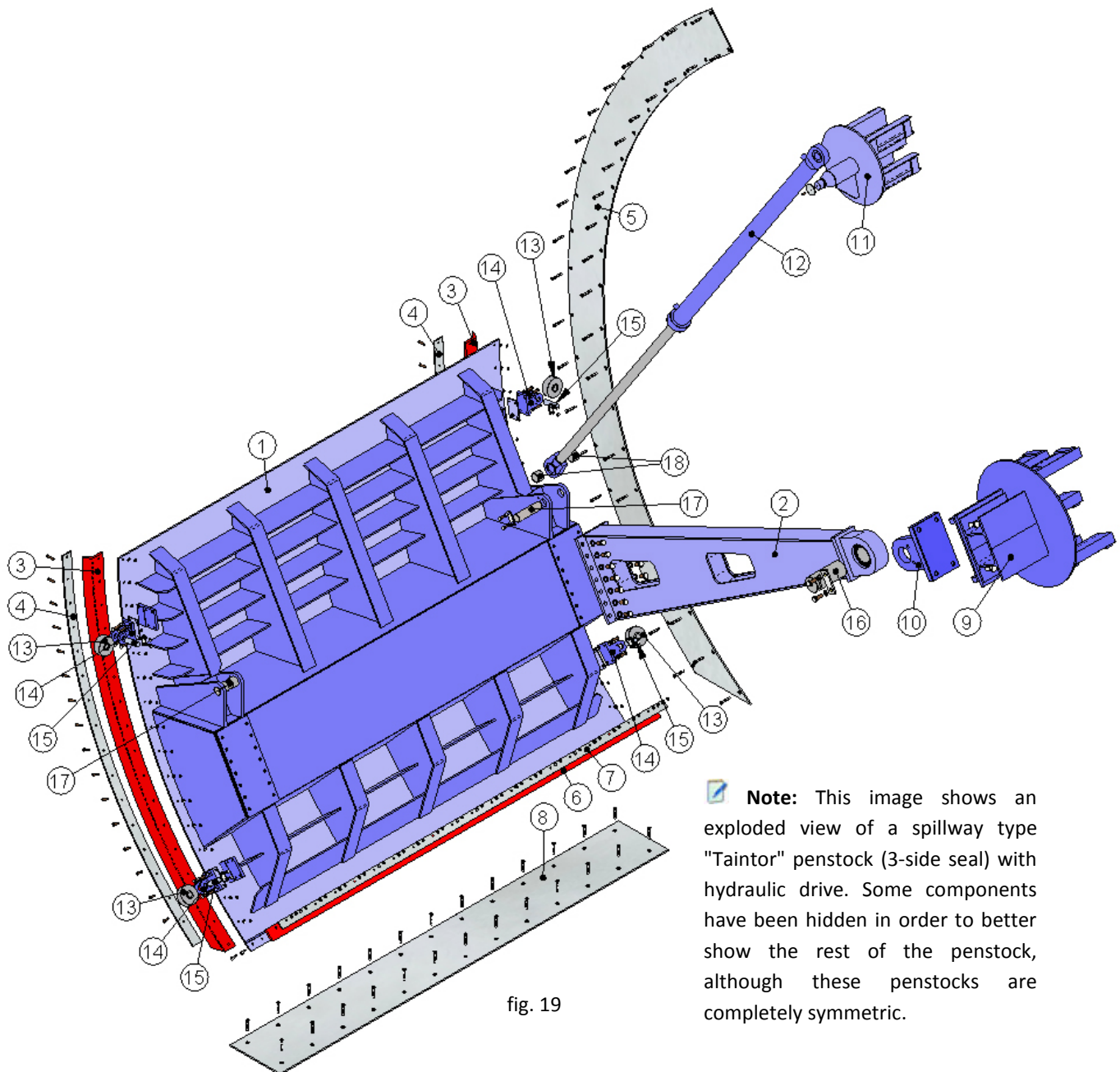


fig. 19

Note: This image shows an exploded view of a spillway type "Taintor" penstock (3-side seal) with hydraulic drive. Some components have been hidden in order to better show the rest of the penstock, although these penstocks are completely symmetric.

STANDARD COMPONENTS LIST					
POSITION	COMPONENT	POSITION	COMPONENT	POSITION	COMPONENT
1	STOPBOARD	7	BASE SEAL FLANGE	13	SIDE GUIDE WHEEL
2	ARM	8	BASE SEAL PLATE	14	GUIDE WHEEL FORK
3	SIDE SEAL	9	TURNING POINT SUPPORT	15	GUIDE WHEEL PIN
4	SIDE SEAL FLANGE	10	TURNING POINT FORK	16	TURNING POINT PIN
5	SIDE SEAL PLATE	11	CYLINDER FASTENING SUPPORT	17	CYLINDER PULL PIN
6	BASE SEAL	12	HYDRAULIC CYLINDER	18	SPACER

Table 2

C.M.O.



CONSTRUCCIONES
METÁLICAS
DE OBTURACIÓN, S.L.

CMO



GESTION DE
LA CALIDAD
CERTIFICADA

QUALITY
MANAGEMENT
CERTIFIED

RADIAL PENSTOCK

CT SERIES

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