

Figure 1 (a) Relationship between current and partial pressure of oxygen in a Clark electrode, and (b) schematic diagram of a TruDO sensor.

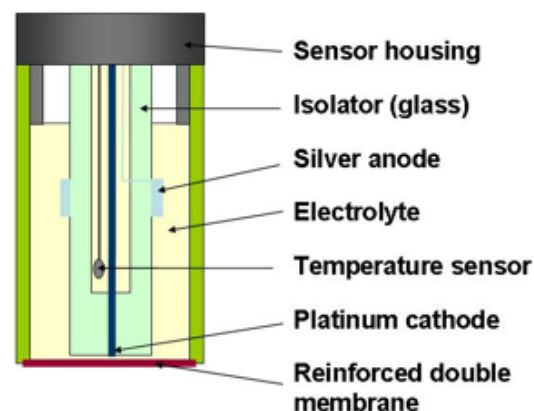
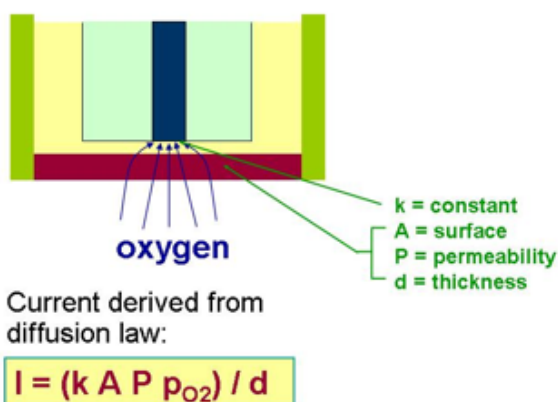
TruDO Sensor Field Service

In this application note, three standard field service procedures for TruDO sensors are described: replacement of the membrane, refilling of the electrolyte solution, and cleaning/replacement of the cathode. Note that the anode cannot be replaced. The dependence of the oxygen measurement on total pressure and position within the bioreactor vessel is also presented.

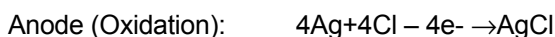
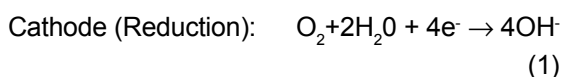
Motivation for Field Serviceability

As described in the technical note entitled “Dissolved Oxygen Sensor Primer”, DO sensors operate by reducing the dissolved oxygen at the cathode surface (Figure 1a), and producing an output current between an anode and a cathode that is proportional to the oxygen content of the

liquid sample. TruDO sensor cathodes are covered with a gas permeable membrane, so that any oxygen diffusing through the membrane is completely reduced at the cathode (Clarke’s principle). A schematic diagram of a TruDO sensor is shown in Figure 1b.



For Clarke cell sensors (such as TruDO) constructed using Ag/AgCl and platinum electrodes and using KCl electrolyte, the detailed oxygen reduction reaction at each electrode is:



From equation 1, it can be seen that every time oxygen is reduced, 4 electrons are generated and the cathode is “depolarized”. These electrons lead to a current that is related to the partial pressure of the dissolved oxygen.

Servicing of TruDO sensors must be carried out on a regular basis because the measuring process consumes or contaminates the sensor’s “active” components. Specifically:

1. The electrochemical reaction consumes electrolyte solution in the sensor head, so that electrolyte levels must be checked and replenished

2. The membrane may become dirty through gradual biofouling that cannot be entirely removed during the sterilization process. The membrane may also be deformed by the sterilization process and handling. Therefore, the membrane should be regularly replaced.
3. Finally, if the membrane develops micro-fissures or microscopic holes, or even ruptures during a process, the cathode can also become biofouled and must be cleaned or replaced.

If the anode becomes contaminated or detaches from the cathode, the entire sensor must be replaced. Also note that the TruDO sensor must be sterilized after being serviced, and prior to being used in a bioprocess.

The procedures required for services 1 through 3 are described in this application note. TruDO sensors have been designed for easy and fast field servicing by the end user. Finesse also offers fast turnaround sensor services, including probe rebuilding, quality verification, and certification for all TruDO sensors (see www.finesse-inc.com/services).

Additionally, after being serviced and/or sterilized, TruDO sensors should be recalibrated with the transmitter with which they will be used in order to enhance their performance. This will minimize error and to maximize accuracy and reproducibility. The calibration should be performed with the TruDO sensor in the actual process media, in order to compensate for any overpres-

sure in the bioreactor vessel (due to aeration or sparging), and for any differences in membrane permeability between air and the aqueous solution. Furthermore, in order for the transmitter to correctly convert the sensor's current output to % saturation, the transmitter must know the process operating temperature and pressure of the sample media.

General Field Service

General field service includes replacing the membrane, refilling the electrolyte, and cleaning the glass body of the electrode. When servicing TruDO™ sensors in the field, please use the “Membrane Replacement Kit” (Part Number: DOS-MEM-12 or DOS-MEM-25) shown in Figure 2, and supplied by Finesse. If replacement parts or solutions from other suppliers are used, the performance of the TruDO™ sensor can no longer be guaranteed.

When changing the membrane or refilling the electrolyte, it is highly recommended that safety goggles and protective gloves be worn. If mechanical damage to the membrane occurs during field service, the electrolyte may leak out. Contact of the electrolyte with skin, eyes or other mucous membranes is to be avoided.

Assembly and maintenance must only be done by trained personnel. For details on training courses, please contact your Finesse representative, or visit www.finesse-inc.com/services. Since the inner part of the sensor is glass, handle it with care. The top of the sensor can be damaged by mechanical shock.



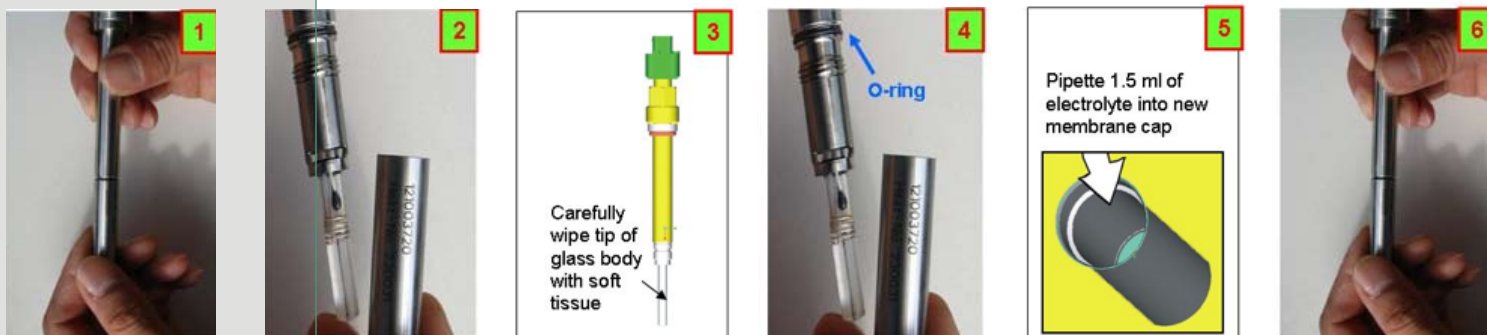
Figure 2 Membrane replacement kit for TruDO™ sensors.

When changing the membrane or refilling the electrolyte, it is highly recommended that safety goggles and protective gloves be worn. If me-

The membrane cap is replaced as follows (see figure 3):

1. Put the sensor in an upright position and carefully unscrew the membrane cap.
2. Remove the membrane cap, exposing the glass body of the electrode.
3. Carefully clean the tip of the glass body with a soft tissue (e.g., a Kimwipe).
4. Check the small O-ring above the glass body. Replace it if it is damaged.
5. Use the 1 ml plastic pipette from the membrane replacement kit to pipette 1.5 ml of electrolyte (DOS-SOL) into the new membrane cap.
6. Carefully screw the new membrane cap onto the sensor shaft. Any spillage of electrolyte should be rinsed away with water.

Figure 3 Membrane replacement and electrolyte refill procedure: unscrew the old membrane cap, fill with 1.5 ml of electrolyte solution, and screw on new membrane cap.



TruDO



Figure 4 Cleaning a contaminated cathode by pressing the green polishing strip lightly against the glass and turning it 10 to 20 times.

Figure 5 Electrode replacement procedure: unscrew the old membrane cap, fill with 1.5 ml of electrolyte solution, and screw on new membrane cap.

The electrolyte can be refilled by following steps 1, 2, 5, and 6.

The cathode can be cleaned by following steps 1, 2, 3, and 6. If gently wiping the electrode does not help, the cathode is likely contaminated and a more aggressive cleaning process should be substituted for step 3. In this case the cathode and the polished part of the glass body need to be cleaned with the polishing strip included in the membrane kit:



ATTENTION

Mechanical polishing of the cathode should only be done with polishing strips supplied by Finesse in the membrane replacement kit. Do not touch the anode wire. Do not bend the glass body.

Electrode replacement

TruDO sensors have a unique, modular design that allows the entire electrode to be replaced in the field. When the cathode can no longer be cleaned to achieve the desired performance, or the anode has become detached from the glass, the TruDO sensor can be rebuilt with a new electrode.

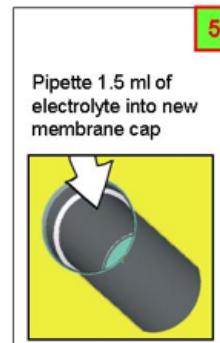
1. Take the dry polishing strip (green paper in Figure 2) in one hand; then press the sensor lightly into the polishing strip and rotate it 10-20 times (see Figure 4).
2. Afterwards, rinse the glass body under running water and carefully dry it.

After being serviced, the TruDO sensor should be sterilized and recalibrated together with its transmitter prior to use in a bioprocess. Please refer to the application note entitled "Calibrating TruDO Sensors".

Assembly and maintenance must only be done by trained personnel. The electrode of the TruDO sensor is made from glass. It is delicate and can be damaged by mechanical shock, so it must be handled with care. Always wear goggles and appropriate safety gear when servicing TruDO sensors.

The cathode is replaced as follows (see figure 5):

1. Put the sensor in an upright position and carefully unscrew the membrane cap.
2. Remove the membrane cap, exposing the glass body of the electrode.
3. Grasp the metal directly above the glass body and remove the cathode assembly by carefully pulling it away from the sensor body.
4. Reverse the process to insert the new cathode assembly. Take care to align the connector before insertion
5. Use the 1 ml plastic pipette from the membrane replacement kit to pipette 1.5 ml of electrolyte (DOS-SOL) into the new membrane cap.
6. Carefully screw the new membrane cap onto the sensor shaft. Any spillage of electrolyte should be rinsed away with water.



After any service is performed on a TruDO sensor, it should be sterilized and recalibrated with its transmitter prior to use in a bioprocess. Please

refer to the application note entitled "Calibrating TruDO Sensors".