



TROJAN DRY OUT SYSTEM (TDOS) Operating Manual

TDOS 1000 HV Dry Out System
Intellirent

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TDOS - Operating Manual

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General Description

The Trojan Dry-Out System (TDOS) is an active transformer Analysis, Degassing and Water Removal Dry Out system that can be connected to the oil volume in the transformer main tank while it remains energised.

It is specifically designed for removing dissolved water from the oil. **It is not** designed to remove free water from the bottom of transformers, and will shut down if the relative saturation of the oil is above 95% for 5 seconds. Free water will cause the filters to swell up and become difficult to remove.

Always remember that connecting, commissioning and operating the TDOS on energised transformers requires absolute care and thorough pre-planning and inspection. Follow the connection, commissioning and operating instructions carefully and do not proceed at any point unless you are satisfied that your actions will be successful and not risk the transformer's integrity.

Don't take risks. Spend as much time as is required to satisfy yourself that all connection points are safe and tight before starting, commissioning and departing the site.

The TDOS has multiple shut down mechanisms and alarms in the event that operation is less than ideal.

If in doubt at any time contact the manufacturer for advice

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IMPORTANT

To Stop the Trojan Dry Out System (TDOS) at any time

- Push the Stop button on the control cabinet
- Turn the main external power switch "Off"

In the event of a fault you DO NOT need to drain the TDOS.

Unless stipulated as an instruction on the PLC screen.

Storing the Trojan (or when not in use for a long period of time)

If the Trojan Dry Out System is to be stored or left unused for any length of time, all oil should be drained from the system using the "Full Drain" Cycle prior to being stored. To ensure all oil is removed, at the completion of the Drain Cycle, open both the Trojan Inlet & Return Valves, draining the oil into a clean container.

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1. Arriving at the site that the Trojan TDOS is to be used

Important Note: Transformer Oil Volume

Before connecting the TDOS to the transformer, confirm the oil volume of the transformer main tank.

It is recommended that the TDOS 1000 LV / HV should not be operated on transformers with a main tank oil volume less than 2,000 litres / 528 US Gallons. During the different treatment cycles, the oil level in the transformer will alter, and consideration must be given to this factor.

If the oil volume is lower than 2,000 litres / 528 US Gallons, contact Trojan directly to discuss options on how to proceed.

Once arriving on site, before final positioning of the TDOS in the substation, check that you have clearly identified the valves on the transformer that the TDOS oil hoses will be connected to. These valves must be above the sedimentary sludge line and any free water that may be at the bottom of the transformer.

Open both the transformer oil valves and flush some oil into a bucket to confirm that the oil is free from sludge and free water. This is very important. Then position the TDOS close to the transformer and central to the two oil connection points on the main tank.

Trailer Mounted:

If the TDOS is trailer mounted position the oil hose access side of the trailer closer to the transformer oil valves.

When in position, uncouple the TDOS from the vehicle and lower onto the jockey wheel at the front of the trailer. Adjust the jockey wheel so that the TDOS is level, and alter the two rear stabilizers to lock into this position. This is important, as it ensures that any oil leaks are directed into the sump cup and will activate the Oil Leak level switch.

2. Power Supply and Connection

For Voltage & Phase information on this TDOS unit, refer to the Power Supply Nameplate located above the power supply point on the outside of the canopy.

As a guide: For 230 V, single phase, 25 amps supply is required; for three phase 208V, 20 amps per phase is required; and 400v or 415v three phase, 16 amps per phase is required.

When the TDOS main switch is turned on after power connection, check the PLC screen to confirm if the phasing connection is correct.

3. Connecting the TDOS Oil Hoses to the Transformer

Caution – Flush free water and sludge

Before connection the oil hose, always open both transformer valves that you are intending to connect to and run a few litres of oil into a container to ensure that sludge and free water are removed completely. Keep running the oil until the oil flows free and clean.

This is very important. Make sure that with the high volumes of oil being pumped by the TDOS that sludge and other matter at the bottom of the transformer will not be sucked down the Inlet hose.

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Confirm that oil is available at both valves. You will be required to confirm this point when going through the Commissioning Cycle.

Oil level in the transformer - Check the oil level in the transformer when flushing the transformer valves before connecting the hoses.

Best oil connection points on the transformer

Inlet hose - It is important that the **inlet hose** (from the transformer to the TDOS) be connected to a valve near the **bottom** of the transformer main tank, or bottom of the radiators. This is so that the coolest oil is entering the TDOS. Recommended **Inlet** hose connection points are:

1. At or near the bottom of the main tank
2. A valve at the bottom of the cooling radiators.
3. Above the sludge and free water line – make sure the valve is clear of these contaminants.

Connecting at the bottom of the transformer will give the highest relative saturation of water in the oil. This is ideal for the best water removal performance of the TDOS.

Return hose - The **return** oil line (from the TDOS to the Transformer) can be connected to the bottom of the conservator (preferred) or at any point on the main tank or radiators away from the Inlet hose, and where it will not stir up sludge. Preferably, this hose will be connected into the top oil area.

Conservator type – make sure that you are connecting the **return hose** valve to a “wet” valve, such as the conservator drain valve. If the transformer has a Buccholz, bleed any bubbles before you start the Commissioning cycle and then again after the TDOS has started the first of the treatment Cycles.

Nitrogen blanketed type – make sure to confirm if there is oil level at the top oil valve. You will be required to make a selection when commissioning the TDOS to confirm that the top connection has oil at this valve.

NB: The Bypass hose will need to be installed (Section 7 below) when connecting to a transformer where oil is not present at the top (**return**) valve.



Inlet supply to the Trojan



*Return line to the transformer (top valve on main tank – hang return line valve vertical whenever possible) **Note Flush Hose***

The photographs above are good examples of how to connect the valves.

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Oil hoses

Two hoses are supplied: both are $\frac{3}{4}$ " in size. The hose with the **blue** bands is the **Inlet** oil to the TDOS, and the hose with the **Red** bands is to **Return** the oil to the transformer.

End caps / plugs have been supplied to prevent oil leaking from and dirt entering the hose during non-use periods and when the TDOS is being transferred between transformers. The orange electrically opened (spring closed), isolation safety valves are to be located at the transformer end of each hose.

The TDOS end of each hose (connects to the Trojan Inlet & Trojan Outlet Valves) has small "holes". This is to allow any oil contained in the outer hose to drain into the TDOS sump and activate the sump level switch.

Take care to ensure that the orange isolation valves are **NOT** attached to the end of the hose with the small openings.

- Screw the flanged $\frac{3}{4}$ " male pipes / flanges supplied into the respective transformer drain valves using suitable reducers and pipe thread sealant accordingly.
- Where possible, hang the orange ball valves vertically as shown in the photo above.
- Bolt the flanges together using the gasket supplied and check the quality of the gasket each time the Trojan is removed. Be mindful of the best natural hang position and bolt tight evenly.
- Before inserting the oil hoses through the Trojan cover, insert the electrical plugs from the Orange safety valves through the Return hose hole and plug them into the colour coded female plugs
- Then insert the hoses through the cover, and before you tighten the hose connections, tidy the hoses so that they lay evenly, unstressed with no twists and large even bends. Then make sure all connecting points are adequately tightened using two spanners.
- When the hoses and connections are tight, open both the **Inlet and Return** ball valves on the Trojan where the hoses connect to.

Main actions – Connecting the oil hoses to the Transformer

1. **Flush the oil from both valves** on the transformer prior to connecting the hoses to remove all free water & / or sludge from these access points.
2. The **Inlet** hose (oil to the TDOS) is always connected to a valve at or near the bottom of the transformer.
3. The **Return** hose (oil from the TDOS) is always connected to the top of the transformer, preferably into a "wet" valve.
4. The orange safety ball valves at the Transformer end of the hoses must be plugged into the colour coded electrical plugs in the Trojan.
5. The main power supply to the Trojan is connected. Incorrect 3 phase connection will show on the PLC screen.
6. Check that there is adequate oil in the transformer.

DO NOT OPEN THE OIL VALVES ON THE TRANSFORMER THAT THE HOSES ARE CONNECTED TO UNTIL INSTRUCTED BY THE TROJAN PLC SCREEN DURING THE COMMISSIONING CYCLE.

The commissioning cycle will draw approximately 60 litres / 15 gallons of oil from the transformer to fill it up from fully drained.

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4. TDOS Valves - Locations / Colours / Positions



The valve positions noted below are typical for when the TDOS is in operation.

The requirement for the valve positions to change may occur during the Drain Cycle, or at other specific times. The Operator will be instructed via the PLC Screen on which position to move which valves to.

Green Valve – Air inlet into the Trojan during Drain cycle – normally **closed**

Trojan Inlet Valve – 3/4" fitting - **Blue Valve** - Oil Inlet from transformer - normally **open**

Trojan Outlet Valve – 3/4" fitting – **Red Valve** - Oil Return to transformer - normally **open**

2nd Inlet Valve - small **Blue Valve** - Second Inlet for transformer top up and Return Line Hose flushing - normally **closed**

2nd Outlet Valve - small **Red Valve** – Used for outlet oil sample, or to drain system without disconnecting oil hoses – normally **closed**

Electrical Plugs for Orange Safety Valves

- **Blue** plug is for **Inlet** oil to Trojan from transformer.
- **Red** plug is for the **Return** oil to the transformer

5. Selecting the Options on the TDOS PLC Touch Screen.

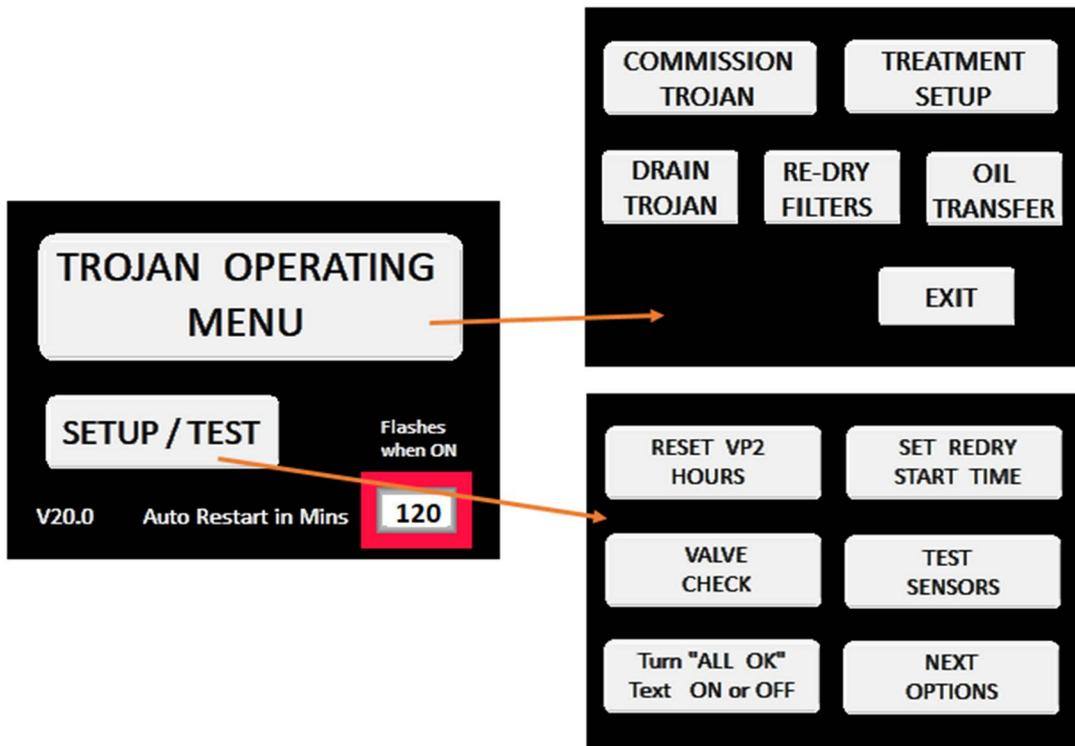
Operation of the TDOS is conducted via the touch screen HMI.

This will guide operators through the Commissioning Cycle, Treatment Cycle Selection, and the Drain Cycle, as well as provide capability to test certain functions and components.

When the power supply is switched on, the Home Page screen will be displayed (shown on below left). If the power supply is disrupted during operation, the TDOS will return to the Home screen when the power supply returns.

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Main Trojan Menu – This button advances into the main process selection screen.

1. **Commissioning** – used when commissioning the Trojan to the transformer.
2. **Treatment Setup** - allows the set-up of Analysis, Degassing; and Water removal cycles to be set up.
3. **Drain Cycle** –when the Trojan needs to be drained to remove from the transformer or change the water removal filters.
4. **Re-Dry Filters** – use after installing a new set of water removal filters, before treatment programs.
5. **Oil Transfer** – use when there is a requirement to transfer oil with the TDOS

Trojan Set up Options – advances into the set-up options such as

1. **Clear Data Memory** – clears all stored treatment data from the memory
2. **Set Filter Re-Dry Start time** – for optimal water removal efficiency
3. **Valve Check** – checks all valves are operating correctly
4. **Test Temperature sensors** – tests these are working correctly
5. **Turn "All Ok" Text ON or OFF** – The "All OK" message can be send daily to confirm the TDOS is operating correctly
6. **Next Options (On the next screen)**, (includes Test Oil Pump, Vacuum pump #1, Vacuum Pump #2 (Optional), Cooling Fans, and Cabinet Heater (Optional).

Further information is provided on the Trojan Main menu and Set UP Options through this manual.

6. Commissioning the TDOS to a Conservator Type Transformer

I.E: There Is Oil at the Top Valve where the TDOS Return hose connects

Important

- Confirm the oil volume of the transformer main tank to ensure it exceeds 2,000l / 528 US Gallons (as per Section 1).
- The TDOS should be empty (have no oil in it) before starting the Commissioning Cycle
- ALWAYS commission the TDOS to the transformer after connecting the oil hoses. Commissioning must be performed before starting the Treatment or other cycles.
- Once the TDOS has been commissioned to the transformer you DO NOT have to re-commission it again, unless you have fully drained the TDOS.
- Only Re-Dry the water removal filters if the TDOS has been commissioned; the valves are all in the correct position; and the transformer valves are open.
- **NOTE:** Turn the "Auto Restart" switch to the OFF position while commissioning the TDOS.

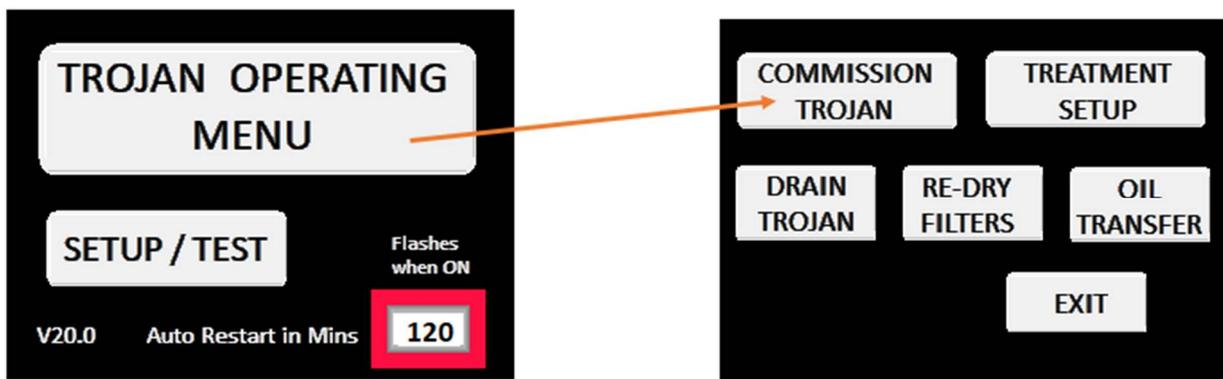
Commissioning Process

Do not allow yourself to be distracted. If two people are on site, one must take full control of the process and operate from the TDOS control cabinet and instruct the other punctually at critical times making sure that the screen instructions are followed carefully, and that the various indicators are met.

Commissioning MUST be performed whenever the TDOS is connected to a transformer, or if the TDOS has been fully drained of oil for a Filter change or to rectify a fault.

Starting Commissioning

From the Home Page screen – select the "Main Trojan Menu" to get to the first of the options screens.

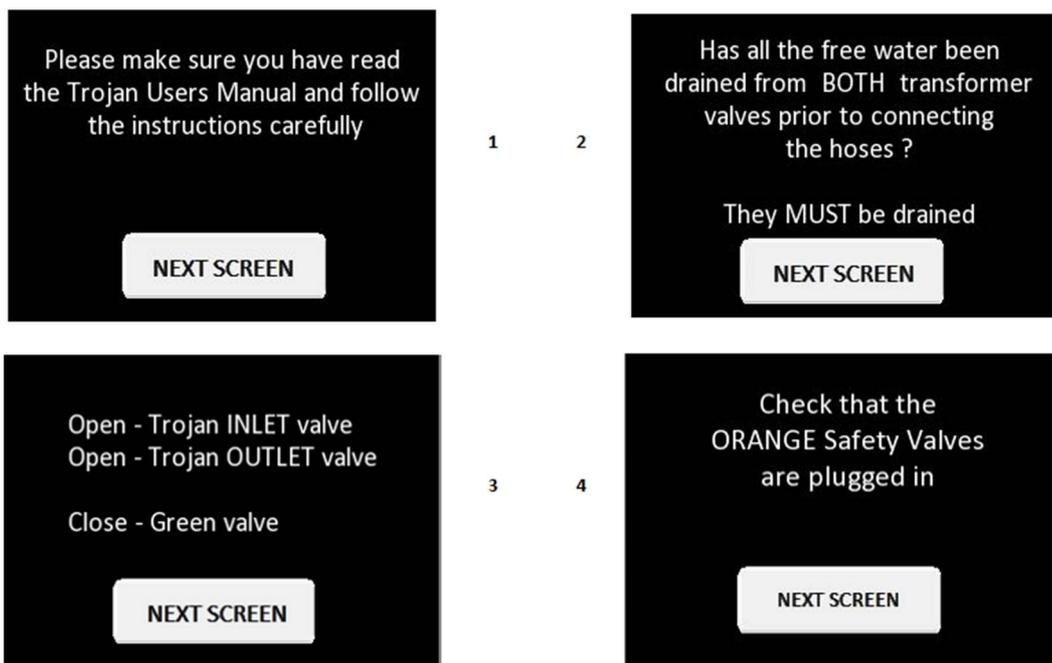


Press "Commissioning". This will start a number of check lists / prompt screens that will have the operator confirm that the TDOS is ready to Commission to the transformer.

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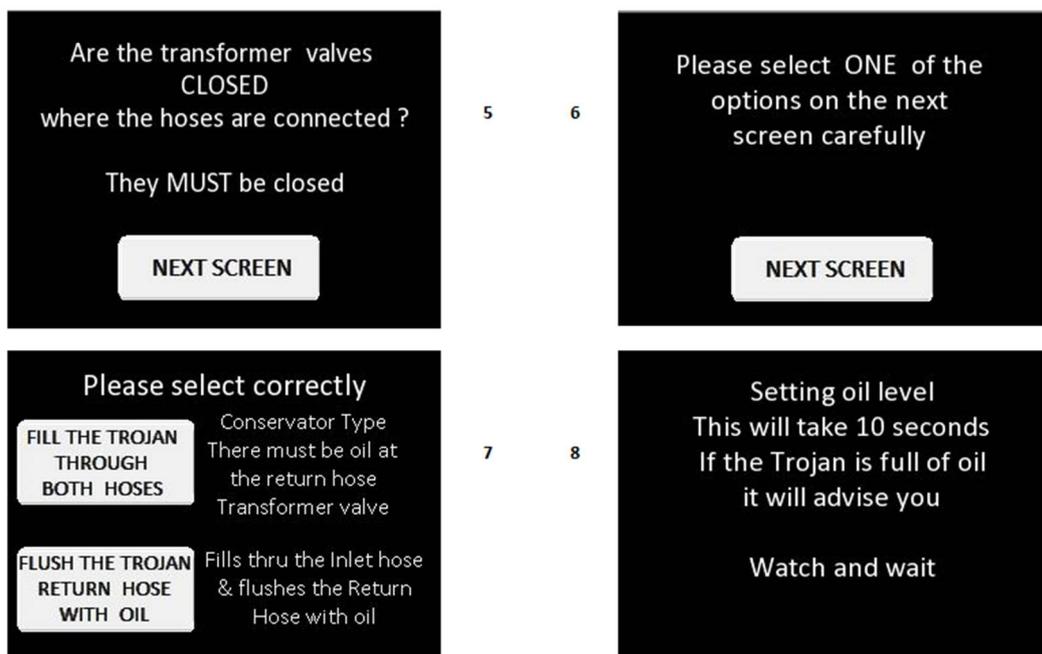
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Commission check screens # 1 to # 4



Follow the prompts and check that all of the valves and other check points are correct before moving to "Next Screen"

Commission check screens # 5 to # 8



The selection on **screen # 7** is important. It is asking if there is oil at the top transformer valve (where the TDOS **Return** hose is connected to) – this would have been confirmed when draining oil into a bucket earlier.

If the top valve is "dry" or above the oil level in a nitrogen blanket (or any) transformer then select the "No Oil at Top Valve", and follow the separate Commissioning instructions in Section 7 (below) for this process.

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When **screen # 8** is displayed, the TDOS has started the commissioning process and is setting its internal oil level to confirm that the system has been drained previously. This takes a minimum of 10 seconds.

If the TDOS has not been drained properly at the last use and there is too much oil in the TDOS for safe commissioning Fault Screen shown below will appear.

Commission Fault Screen - Full of Oil



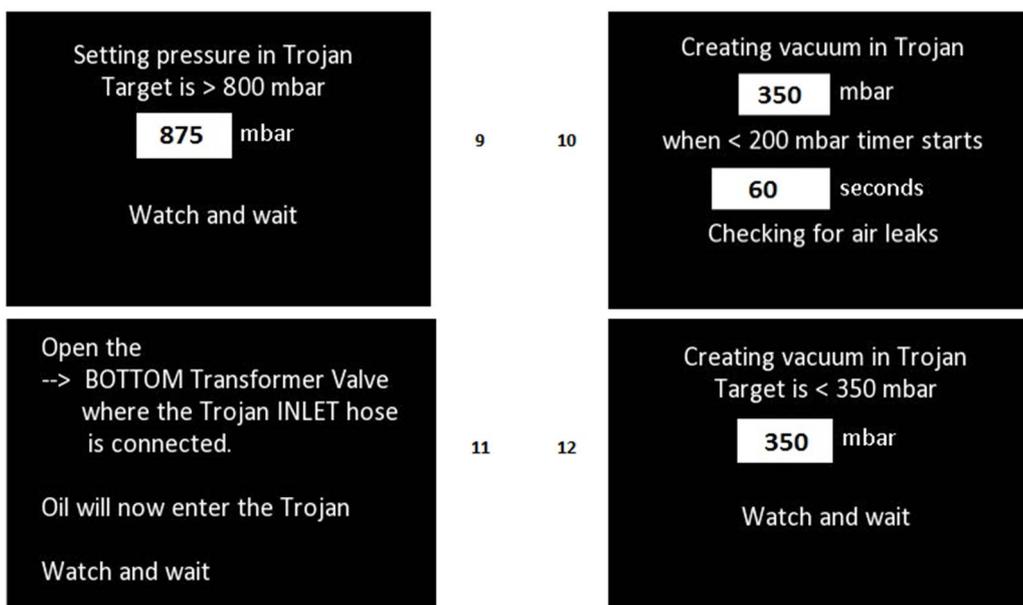
To clear this fault, oil will need to be drained from the TDOS. This can be achieved in by unbolting the flange holding the return hose to the transformer valve and place the hose end over a suitable oil drum of over 90 litres / 23 gallons capacity.

Select the "Drain Cycle" on the PLC screen, follow the instructions to drain the TDOS and allow you to commission the TDOS successfully.

Following the drain process, re-connect the TDOS return hose to the transformer valve and re-start the commissioning process.

If the TDOS had previously been drained correctly, then **screen # 9** (below) will have appeared after **screen # 8**.

Commission screens # 9 to # 12



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Screen # 9 will set the pressures inside the TDOS to the correct level before starting Vacuum Pump # 1. This may take a few seconds and you may see the pressure rising on the screen. To speed up the air pressure increase inside the Trojan, open the ¼" air Bleed Valve at the right top of the vacuum line tank then close it quickly and tightly when the vacuum pump starts.

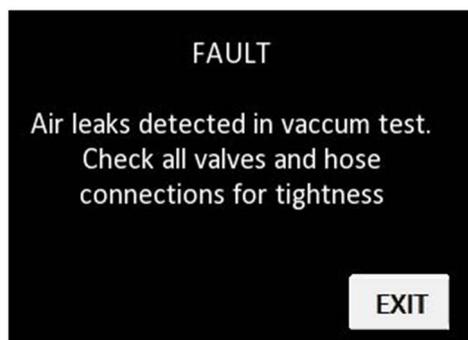
If the TDOS is at the correct pressure it will quickly bypass **Screen 9** and go directly to **Screen # 10**.

Screen # 10 will start Vacuum Pump # 1, which will create a vacuum inside the TDOS - this includes the oil hoses right up to the transformer valves. The Orange safety valves will open now: conduct a visual check to confirm.

When the vacuum is at the correct level, the valve between the vacuum pump and the TDOS tanks will close and the 60 second timer will start counting down. You will be able to see the pressure value alter on the HMI screen.

If there is an air leak and the pressure rises to above **350 mbar**, the TDOS will stop and the following **screen** will appear.

Commission Fault Screen – Air Leak



Air is entering the Trojan or hoses etc, check all hose connections for tightness, make sure the valves on the Vacuum line tank are closed, etc and restart commissioning.

The Air leak screen is activated if:

1. there is a leak in the hoses or connections to the transformer causing an increase of internal pressure and the value of P1 rises above 350 mbar, the fault "air leak" screen will occur, shutting the Trojan down for attention.

2. If the 60 second timer does not start within five minutes after starting the commissioning cycle, the same "air leak" screen will occur.

If the "Air Leak Fault" screen occurs, it is because there is an air leak in the system.

Possible causes may be;

- Connecting hoses and joints may have loose connections.
- Vacuum line tank valves may be open (two small red valves).
- Green Valve is open;

Check the system again, including all valve positions, and restart the Commissioning Cycle

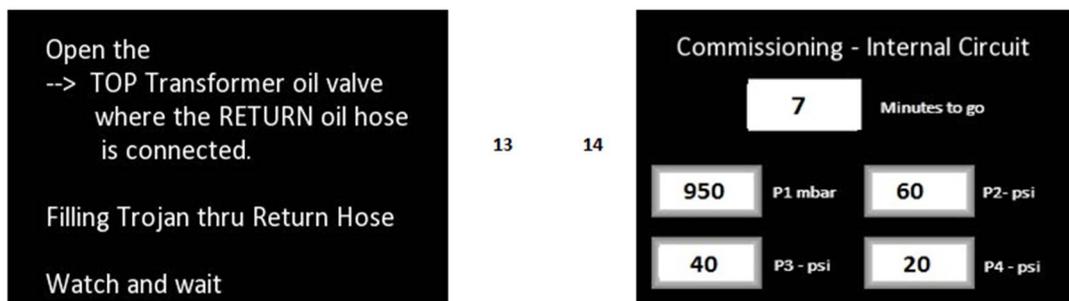
If the leak test was successful, then **screen # 11** will appear along with an audible beep. Open the valve on the transformer that the TDOS Inlet hose is connected to. This is the hose connected to the bottom of the transformer main tank or radiators, and it will allow a specific volume of oil to enter the Trojan and flush the oil hose.

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Screen # 12 may appear briefly to reset the vacuum level inside the TDOS before moving to **screen # 13** below.

Commission check screen # 13 and # 14



Screen #13 will advise the operator to open the top valve on the transformer where the return hose is connected. During this process, the TDOS will be filled to the correct oil level through the Return hose before moving to **screen # 14**. No more operator involvement is required when **screen #14** starts.

Screen # 14 is the first of four similar screens / cycles that the TDOS will now perform. The Orange safety valves will now close and the TDOS will go through the internal process of setting its internal oil level, removing all air and gases over a 15-minute period to make the TDOS ready for use. There is no circular oil flow between the TDOS and the transformer at this time.

Fault screens – NO OIL



If no oil comes down oil hoses during the commissioning process when the Bottom and Top transformer valves are asked to be opened and the correct oil level in the Trojan is NOT achieved, a timer will activate and the fault screens above will appear, and the Trojan will stop.

The oil may not be coming down the hose due to either

- The transformer valve not functioning properly, although this fault should have been detected when flushing the valves of contaminants.
- Orange valve not opening due to it not being plugged in or the activator not opening the valve due to malfunction
- A new gasket may have been cut for between the flanges and no centre oil hole has been cut (it has happened!)
- The TDOS Inlet and Return oil valves may be closed
- Oil is not present at the transformer valve that the TDOS **Return** line hose is connected to. Was this checked?

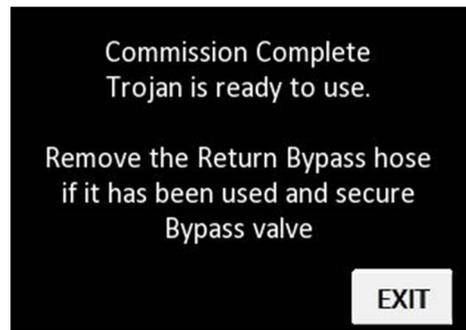
After checking for reasons this may have occurred, re-start the Commissioning process.

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Commissioning Complete

At the completion of the Commissioning Cycle, the TDOS will stop and display the screen below.



This confirms that the TDOS has finished the commissioning process and is ready to be used.

7. Commissioning the TDOS to a Nitrogen Sealed Type Transformer

I.E: There is NO oil at the Top Valve where the TDOS Return hose connects

Important Note # 1: Operating on Nitrogen Sealed Transformers – Internal Pressure

During the commissioning cycle, oil is taken from the transformer to fill the TDOS.

This may create a negative pressure inside the transformer if the nitrogen blanket and internal pressure is not automatically adjusting (i.e.) a bottle with pressure regulator.

It may be necessary to check the pressure before Commissioning, and then set the pressure after the TDOS is running. Then check on a regular basis.

Alternatively – connect a tank with pressure regulator to those transformers that the TDOS is attached to maintain correct internal pressure.

Important Note # 2: Degassing Cycle on Nitrogen Sealed Transformers

If the Degas Cycle is selected on the TDOS when it is operating on a nitrogen blanketed transformer, it is highly likely that nitrogen will be removed.

It may be necessary to check the pressure a regular basis if the TDOS is used in the Degassing Cycle.

Important

- **Confirm the oil volume of the transformer main tank to ensure it exceeds 2,000l / 528 US Gallons (as per Section 1).**

- **The TDOS should be empty (have no oil in it) before starting the Commissioning Cycle**

- **ALWAYS commission the TDOS to the transformer after connecting the oil hoses. Commissioning must be performed before starting the Treatment or other cycles.**

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- Once the TDOS has been commissioned to the transformer you **DO NOT** have to re-commission it again, unless you have fully drained the TDOS.
- Only Re-Dry the water removal filters if the TDOS has been commissioned; the valves are all in the correct position; and the transformer valves are open.
- **NOTE:** Turn the “Auto Restart” switch to the OFF position while commissioning the TDOS.

Commissioning Over View – “No Oil at Top Valve”

When commissioning to a Nitrogen Sealed type transformer, or where the oil is being returned into the top of the transformer main tank, and there is a risk of air entering the main tank. In this instance, use the “No Oil at Top Valve” commissioning process. It differs slightly from that covered in Section 6 above to further reduce the potential for air to be introduced, as oil cannot be brought down both oil hoses during Commissioning (as in Section 6).

The first six (#1 to #6) check screens are identical to the previous commissioning process, but on Screen # 7 you will select the “No Oil at Top Valve” option. This will take you through a series of steps that will ask you to connect a Bypass / Flush hose to the valve at the transformer end of the Return hose, and onto the Second Inlet valve on the Trojan to allow the Return hose to be “Flushed” with circulating oil.

This same Commissioning option can be used when filling the Trojan from a drum or tank where the Return hose connects to a valve where there is no oil behind it. When connecting to a drum or tank, flushing the Return hose is not critical, and in this case the selection options on the screen allow the operator to skip the hose flushing cycle where it is not required, and simply fill the Trojan for oil filtering etc.

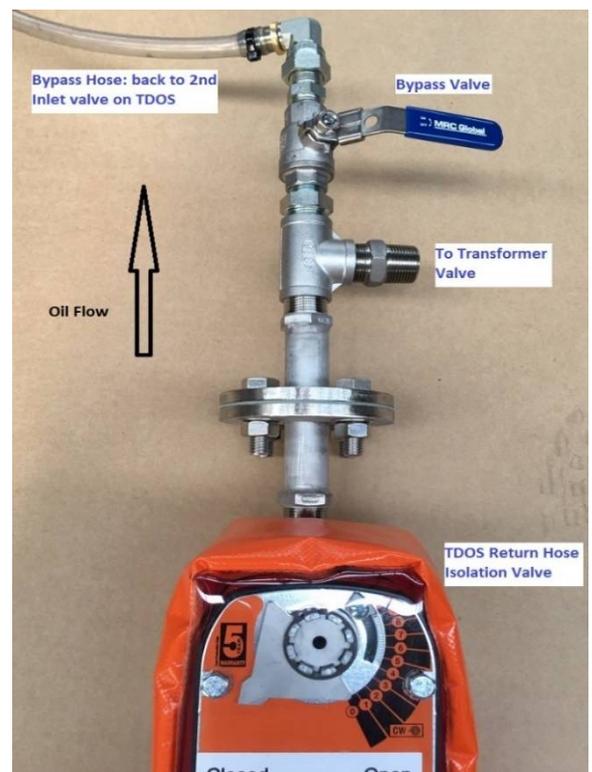
The “No Oil at Top Valve” commissioning Cycle fills the Trojan completely through the Inlet hose, then uses this oil to flush the Return hose to remove air, then continues with the normal internal cycle.

When connecting the Return hose to the transformer, be sure to use the $\frac{3}{4}$ ” Tee with lockable Bypass / Flush Valve attached that is provided (photo below). See correct way to install below.

Commissioning Process

Do not allow yourself to be distracted. If two people are on site, one must take full control of the process and operate from the TDOS control cabinet and instruct the other punctually at critical times making sure that the screen instructions are followed carefully, and that the various indicators are met.

Commissioning **MUST** be performed whenever the TDOS is connected to a transformer, or if the TDOS has been fully drained of oil for a Filter change or to rectify a fault.

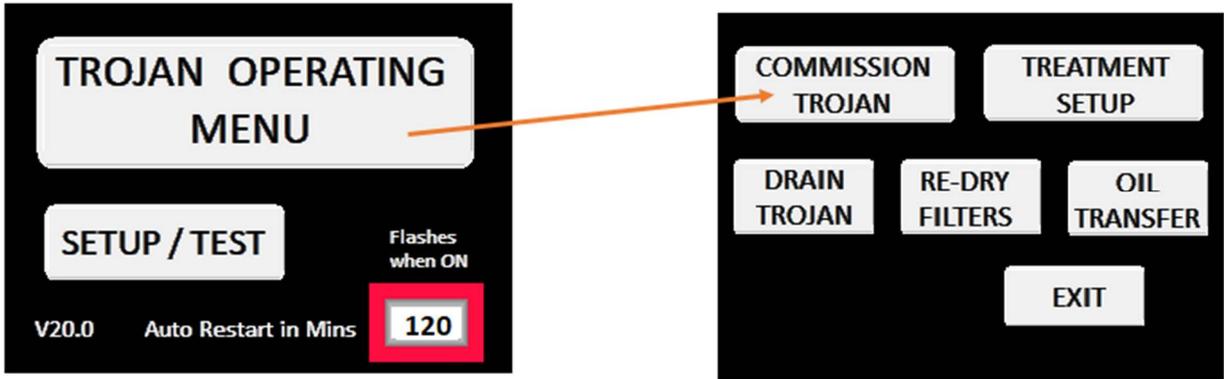


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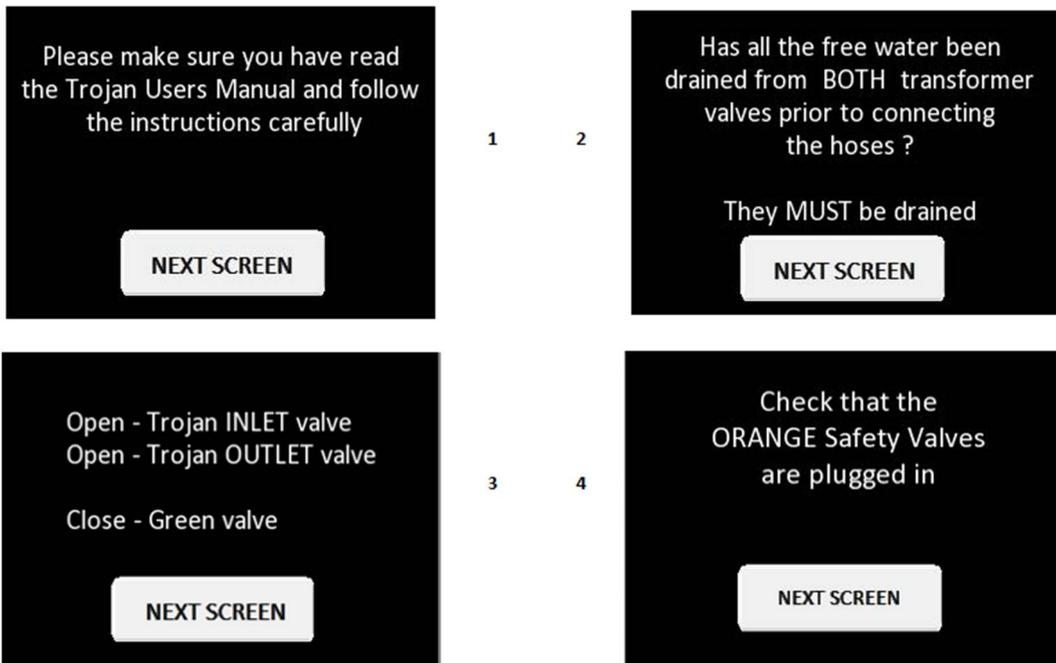
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Starting Commissioning – No Oil at Top Valve

From the Home Page screen – select the “Main Trojan Menu” to get to the first of the options screens. Select and Press “Commissioning”, which will start a number of check lists / prompt screens that will have the operator confirm that the TDOS is ready to Commission to the transformer.



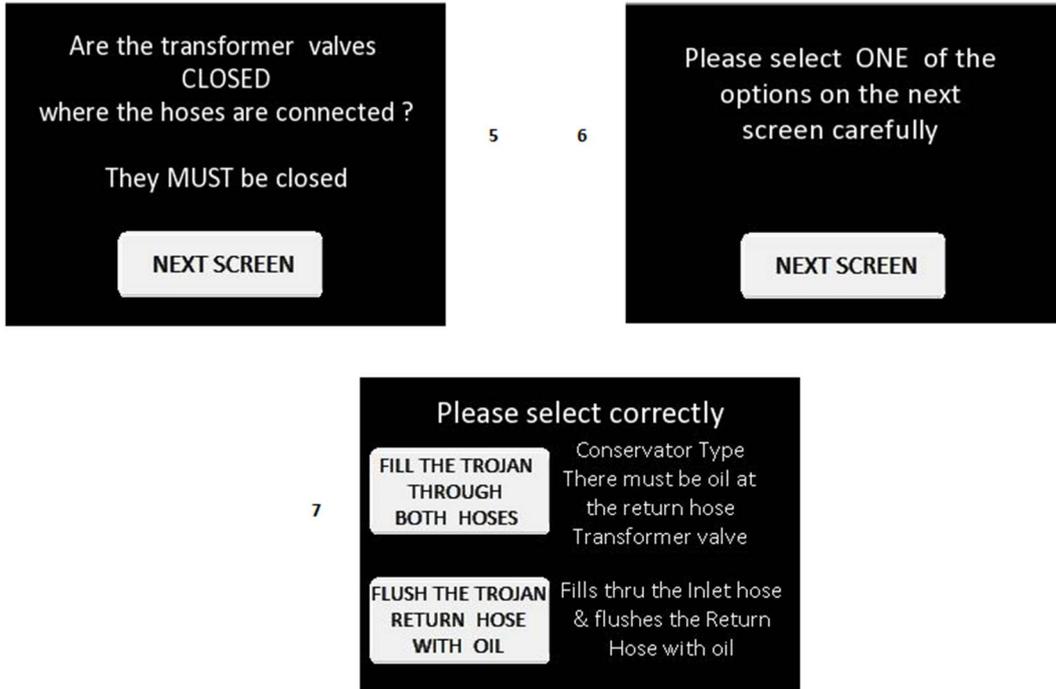
Commission check screens # 1 to # 7



Read and follow the instructions very carefully on screens #1 to #6. Checking valves positions, and opening or closing valves is critical to success, and check that all are correct.

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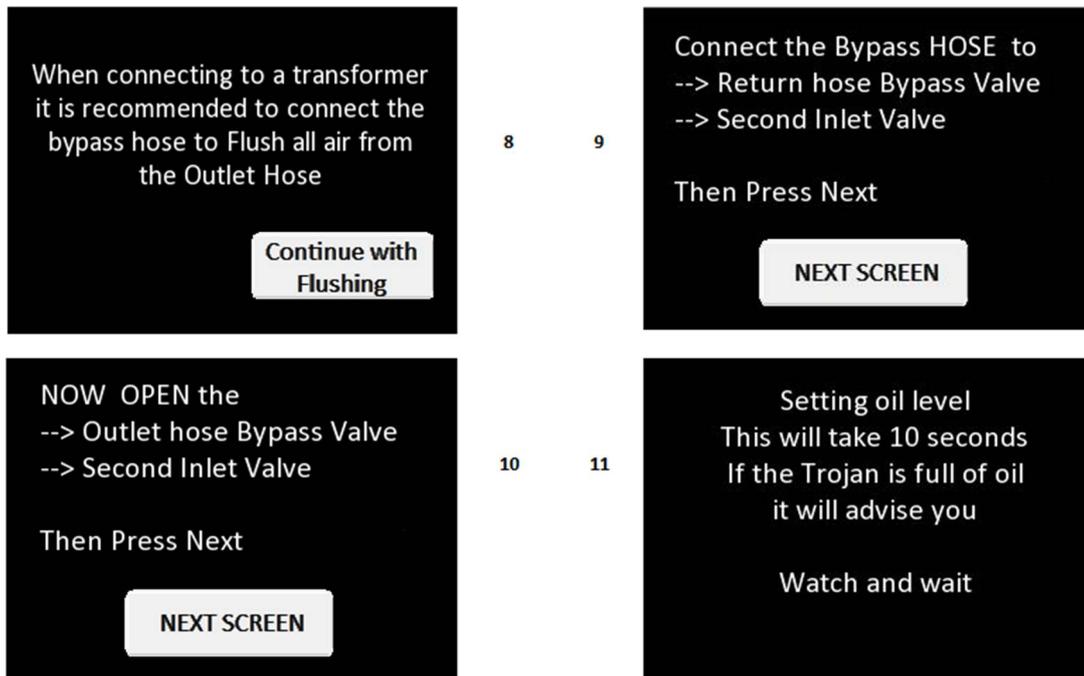


The selection on **screen # 7** is important. It is asking if there is oil at the top transformer valve that the **Return** hose is connected to – this would have been confirmed when draining oil into a bucket earlier.

If the top valve is “dry”, or above the oil level in a nitrogen blanket transformer, then select the “**No Oil at Top Valve**” button. If there is any doubt, and for safety, use this option.

NB: From this point, the Commissioning process differs to that if the “**Oil at Top Valve**” button was selected.

Commission check screens # 8 to # 11



Screen # 8 prompts the operator to select either **Skip** or **Continue** with the flushing process.

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Select “Continue with Flushing” and **screen #9** will then instruct the operator to connect the Bypass hose (black hose supplied) between the Bypass Valve on the **Return** Hose (Safety isolation valve end) and the Trojan Second Inlet Valve, and then on screen #10 to open both of these valves.

Do NOT open the transformer valves until instructed by the HMI Screen.

In both options, the TDOS will still fill only through the Inlet hose.

When **Screen # 11** is displayed, the TDOS has started the commissioning process and is setting its internal oil level to make sure that the Trojan was drained and is empty of oil. This takes a minimum of 10 seconds.

If the TDOS has not been drained properly at the last use and there is too much oil in the TDOS for safe commissioning, the Fault Screen below will appear.

Commission Fault Screen - Full of Oil



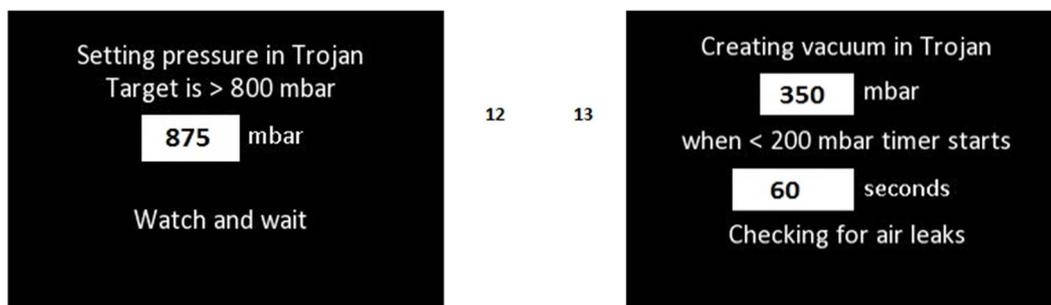
To clear this fault, oil will need to be drained from the TDOS. To do this, simply unbolt the flange holding the return hose to the transformer valve and place the hose end over a suitable oil drum of over 90 litres / 23 gallons' capacity.

Select the “Drain Cycle” on the PLC screen, follow the instructions to drain the TDOS and allow you to commission the TDOS successfully.

Following the drain process, re-connect the TDOS return hose to the transformer valve and re-start the commissioning process.

If the TDOS had previously been drained correctly, **screen # 12** will have appeared automatically after **screen # 11**.

Commission screens # 12 and # 13



Screen # 12 will set the pressures inside the TDOS to the correct level before starting Vacuum Pump # 1. This may take a few seconds and you may see the pressure rising on the screen. To speed up the air pressure increase inside the Trojan, open the ¼” air Bleed Valve at the right top of the vacuum line tank then close it quickly and tightly when the vacuum pump starts.

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If the TDOS is at the correct pressure it will quickly bypass **Screen 12** and go directly to **Screen # 13**.

Screen # 13 will start Vacuum Pump # 1, which will create a vacuum inside the TDOS - this includes the oil hoses right up to the transformer valves. The Orange safety valves will open now: conduct a visual check to confirm.

When the vacuum is at the correct level, the valve between the vacuum pump and the TDOS tanks will close and the 60 second timer will start counting down. You will be able to see the pressure value alter on the HMI screen.

If there is an air leak and the pressure rises to above **350 mbar**, the TDOS will stop and the following screen will appear.

Commission Fault Screen – Air Leak



Air is entering the Trojan or hoses etc, check all hose connections for tightness, make sure the valves on the Vacuum line tank are closed, etc and restart commissioning.

The Air leak screen is activated if:

1. there is a leak in the hoses or connections to the transformer causing an increase of internal pressure and the value of P1 rises above 350 mbar, the fault "air leak" screen will occur, shutting the Trojan down for attention.
2. If the 60 second timer does not start within five minutes after starting the commissioning cycle, the same "air leak" screen will occur.

If the "Air Leak Fault" screen occurs, it is because there is an air leak in the system.

Possible causes may be;

- Connecting hoses and joints may have loose connections.
- Vacuum line tank valves may be open (two small red valves).
- Green Valve is open.

Check the system again, including all valve positions, and restart the Commissioning Cycle

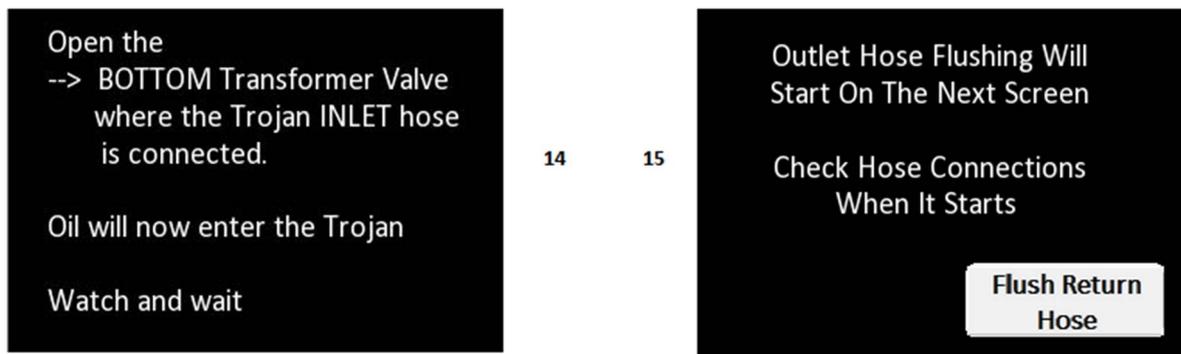
If the leak test was successful, then **Screen # 14** will appear along with an audible beep. Open the valve on the transformer that the TDOS Inlet hose is connected to. This is the hose connected to the bottom of the transformer main tank or radiators, and it will allow a specific volume of oil to enter the Trojan and flush the oil hose.

Screen # 13 may appear briefly to reset the vacuum level inside the TDOS before moving to **Screen # 14** below.

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Commission check screens # 14 and # 15



If the leak test was successful, then **screen # 14** will appear automatically along with an audible **Beep**. **Screen #14** instructs the operator to Open the valve on the transformer that the TDOS Inlet hose is connected to. This is the hose connected to the bottom of the transformer main tank or radiators.

This allows oil to enter the TDOS and will flush any air in the inlet oil hose into the TDOS, from where it will be removed.

The TDOS will now gradually fill to the correct level through the Inlet hose before stopping in **Screen # 15** to confirm that the Flushing process is about to begin.

Selecting “**Flush Return Hose**” will move the process onto **Screen # 16**.

Commission check screens #16 to #17



On Screen #16, the oil pump will start and certain valves on the TDOS will open. Oil, at maximum flow, will circulate out of the Return hose and back into the TDOS via the Bypass hose and Second Inlet valve. The TDOS will remain in this screen for **10 minutes** before stopping and automatically moving to **Screen # 17**.

The operator is now asked to close the Bypass Valve and Second Inlet valve, then select “Next Screen”.

Commission check screen #18



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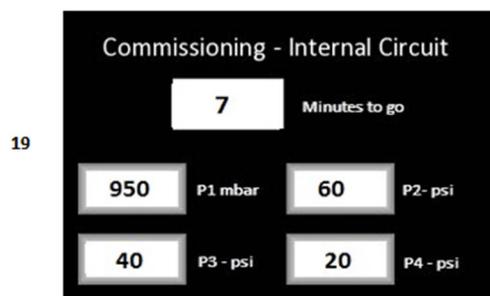
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When "Next Screen" is selected on **Screen # 17**, **Screen # 18** is displayed. This asks the operator to open the transformer valve where the TDOS Outlet hose is connected to (top valve). After completing this task, select "Next Screen" and the Trojan will move to the "Internal Cycle" screens shown below, which are automated internal cycles during which oil is circulated through the Trojan filters, valves and pipe work to remove any air and get ready for the Treatment Cycles.

Below is **Screen 19** (4 similar screens will be displayed). The Orange safety valves will close after setting the oil level inside the Trojan.

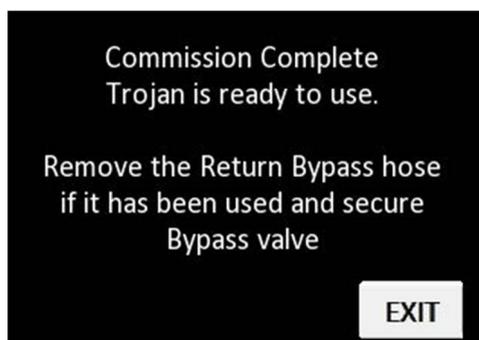
No more operator involvement is required when these screens start. The time in minutes is displayed on the screen identifying how long until the Commissioning process will be completed. There is no circular oil flow between the TDOS and the transformer at this time.

Commission check screen # 19



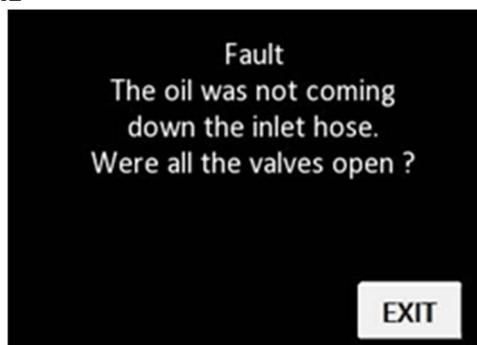
Commissioning Complete

At the completion of the closed circuit cycles the TDOS will stop and display the screen below.



This confirms that the TDOS has finished the commissioning process and is ready to be used.

Commissioning Fault screen – NO OIL



If no or limited oil comes down the Inlet oil hose during **Screen #14** when the Bottom valve is asked to be opened, and the oil level in the Trojan has not been satisfied, at 13 minutes after the start of screen

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14, the Beeper will stay on continuously to alert the operator that it is taking longer than usual, and at 16 minutes the process will stop and show the fault screens above.

The oil may not be coming down the hose due to either

- The transformer valve not functioning properly, although this fault should have been detected when flushing the valves of contaminants.
- Orange valve not opening due to it not being plugged in or the activator not opening the valve due to malfunction
- A new gasket may have been cut for between the flanges and no centre oil hole has been cut (it has happened!)
- The TDOS Inlet oil valves may be closed

After checking for reasons this may have occurred, re-start the Commissioning process.

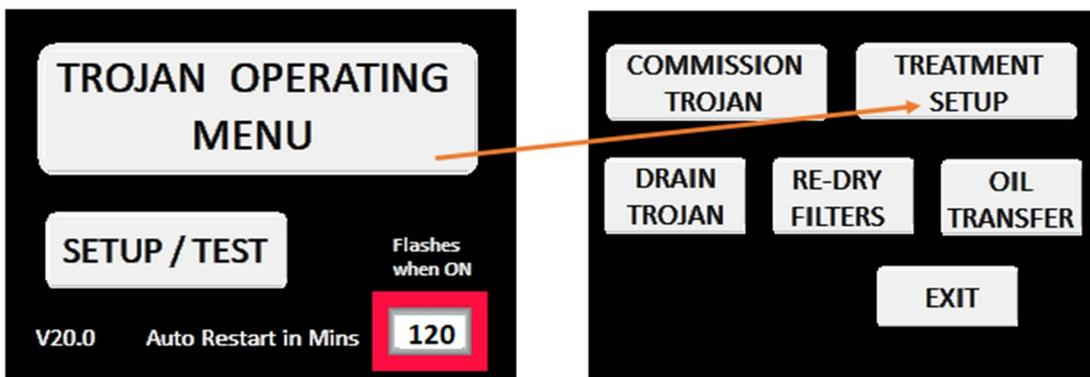
8. Treatment Program SET UP Program – All Transformer Types

Important: The TDOS must be commissioned to the Transformer before you can start the TDOS in the Treatment Program

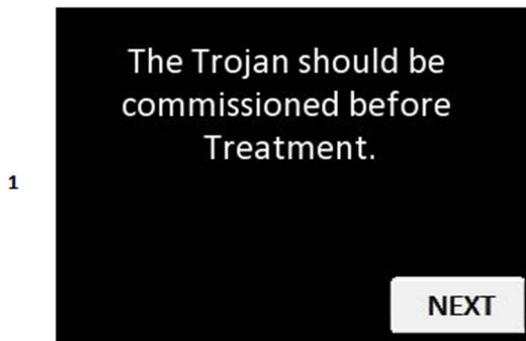
Following Commissioning, the TDOS can be set into a specific Treatment Program.

From the Main Home page

Press the Main Trojan Menu button → Treatment Program to set the cycles required.



Treatment Program Selection Screens # 1

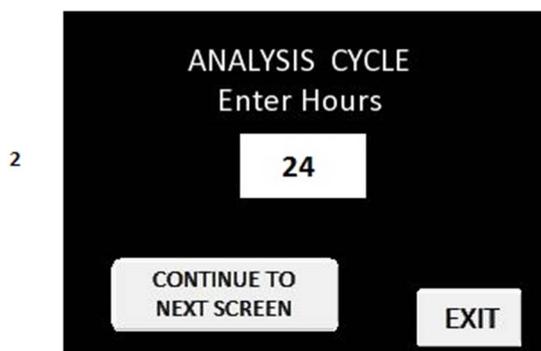


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Screen # 1 will then appear to remind the operator that the TDOS must be commissioned prior to use in the Treatment Cycles. If Commissioning has been completed, press the "Continue to Next Screen" button. If not, refer to either Section 6 or 7 above, and follow the correct process for Commissioning the TDOS.

Treatment Program Selection # 2 - Analysis Cycle



The Analysis Cycle provides you with an extremely accurate starting point and understanding of the real level of moisture contamination in the transformer, as it is online and measured over a period of hours (typically 24 or 48 hours).

Trojan recommends 48 hours for a detailed Analysis interpretation.

During the Analysis Cycle, at 30-minute intervals, the TDOS records the water activity between the oil and the cellulose insulation. Note there is no moisture, gas or acidity removal during the Analysis Cycle.

It is **recommended** to always **start** any treatment program with 24 hours in the Analysis Cycle.

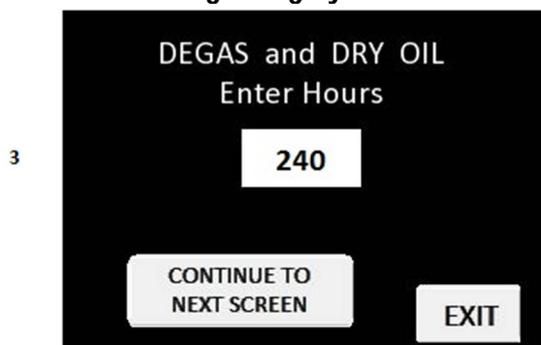
To set the number of hours for the Analysis Cycle, touch the icon under "Enter Hours" and a numeric keypad screen will pop up. Enter the number of hours desired, and then push "Enter".

If no Analysis is required, make sure there are only zeros for the number of hours, then press "Next Screen".

The maximum Analysis time that the PLC screen will accept is 999 hours. Analysis time recommendations are:

1. Transformers with near constant load: 12 or 24 hours,
2. If load can be shifted onto the transformer to being analysed (substation shared load), set the analysis for either 24 or 48 hours, start the Analysis and increase the load.

Treatment Program Selection # 3 – Oil Degassing Cycle



During the Degas cycle, gases, water and particles are removed from the oil.

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If you have a TDOS LV (Low Vacuum model – only one vacuum pump), the maximum level in the vacuum tank will be <80mbar, which will reduce the gas levels down to a certain point.

A TDOS HV (High Vacuum - 2 vacuum pumps) will remove all gases down to very low levels and achieve a vacuum level of <5 mbar.

The oil is not heated during the TDOS degas treatment cycle. Trials & customer results with the TDOS have confirmed that heat is not required to remove gases and water from the oil down to very low levels when the system is used on an energised transformer.

Note that during the degas cycle, the oil will be exposed to vacuum. This will have the effect of altering or reducing the oil DGA.

If you wish to degas the oil, just enter the number of hours you require. If no degassing is required enter zero into the area and then press “Next Screen”.

Gases are removed via the degas elements – located in the TDOS vacuum chamber - which has millions of fibreglass fibres that expose the oil to a large surface area that promotes the release of both gases and water vapour.

The elements will also remove particles down to 5 microns. The degas element life should be up to one year.

The maximum Degas time that the PLC screen will accept is 999 hours.

Note: On the TDOS HV Model, the lubricating oil & other consumables on Vacuum Pump # 2 will need to be changed as per the manufacturers recommended guidelines, as will the exhaust filter and oil filter.

Treatment Program Selection # 4 – Water Removal Cycle



During the Filtering Treatment Cycle, moisture is removed from the oil via large capacity adsorbent filters, which are located in the TDOS filter tank.

During this cycle, these adsorbent filters are automatically redried by the TDOS – with no operator involvement required at all.

Two Filtering Cycles are available: 24 hours; or 36 hours.

The 24-hour cycle should be selected when the transformer has a large oil volume; the oil is “wet” with moisture; or the transformer load profile is high.

The 24-hour cycle is the most commonly used, and we recommend that you use this cycle.

During the 24-hour period, the TDOS continuously draws oil from the transformer and pumps it through the large adsorbent filters, which remove and store the dissolved water. After 18 hours of filtering, the

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TDOS automatically closes the Orange safety valves, stopping the oil flow from the transformer, and then enters a process of automatically Re-Drying the filters.

The Re-Dry cycle lasts for six (6) hours before automatically moving back into the Filtering Cycle again.

This Filtering Cycle / Re-Dry process continues until the TDOS is stopped by the operator.

The process is essentially the same in the 36-hour cycle, with the exception being 30 hours of filtering before the Re-Dry Cycle starts.

Treatment Confirmation Screen # 5 – Treatment Program Confirmation

5

The Trojan will carry out the following Wait - It will start automatically	
Analysis	24
Degas	240
Filter Cycle	24

After the Filtering hours are selected, the treatment confirmation screen will appear for 15 seconds to display what time periods the operator has selected.

After displaying this screen for 15 seconds, the TDOS starts automatically in the first cycle with hours selected.

Based on the Treatment Cycle Confirmation screen shown above, the TDOS will analyse the oil for the 24 hours. It will then automatically move to Degassing, where it will operate for 240 hours, before moving into the Filtering Cycle.

When in the Filtering Cycle, the TDOS will go into its normal cycle of Filtering and Re-Drying the TDOS adsorbent filters until the TDOS is stopped.

If zero hours are entered for the Analysis or Degas Cycles, the TDOS will start on the Water Filtering Cycle. However, it is always recommended to start the TDOS Treatment Program in the Analysis Cycle for a period of 24 Hours.

9. Treatment Program Screens and Abbreviations

Below are typical screens from the different Treatment Cycles. The abbreviations and readings showing the values of the oil entering the Trojan are explained below.

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Pressure		ANALYSIS CYCLE	
950	P1 mbar		
60	P2- psi	Oil Values	
48	P3 - psi	52	Temp
12	P4 - psi	21.9	RH %

		DEGAS CYCLE	
52	P1 mbar		
35	P2- psi	Oil Values	
25	P3 - psi	43	Temp
8	P4 - psi	6.3	RH %

		FILTERING CYCLE	
951	P1 mbar		
55	P2- psi	Oil Values	
45	P3 - psi	35	Temp
10	P4 - psi	2.7	RH %

- **P1** = Pressure in the Buffer and Vacuum tank in millibar (1000 millibar = 1 atmosphere, or 750 Torr). This pressure is normally in a partial vacuum, between 5 mbar and 1000 mbar.
- **P2** = Pressure in the Filter tank before the adsorbent Filters. Normal between 55 psi and 65 psi.
- **P3** = Pressure in psi after the adsorbent Filters.
- **P4** = Pressure in psi of the return oil hose – measuring the head pressure of the return hose transformer oil volume.
- **Temp C** = The temperature of the oil as it enters the Trojan. If the oil connection line is at the bottom of the transformer, this represents the bottom oil temperature.
- **RH %** = Relative Humidity or Relative Saturation of the oil in water (measured on the inlet oil line). The reading is shown as a percentage e.g. 35.6%. 0 (zero is perfectly dry oil and 100% is fully saturated to the point whereby the dissolved water falls out of suspension, like rain).

10. Draining Oil from the TDOS – All Transformer Types

At the completion of the selected Treatment Program, the TDOS will be stopped by the operator. Before moving onto the next transformer, or even if intending to not use the TDOS for a period of time, the oil **must** be drained from the TDOS.

A highly automated, safe and well proven process is incorporated in the TDOS for draining the oil back into the transformer.

The TDOS will not be able to be commissioned to the next transformer unless the oil has been drained.

Important

- **Undertake the Drain Cycle before removing the TDOS from a transformer and moving to another location (whether it will be commissioned to another transformer or not)**
- **In event of a Fault, you do not need to drain the TDOS unless stipulated in the fault alarm instructions**
- **Consider where the oil will be drained to?**
 - Into the transformer (preferred option) - In this case leave the return hose connected to the Transformer

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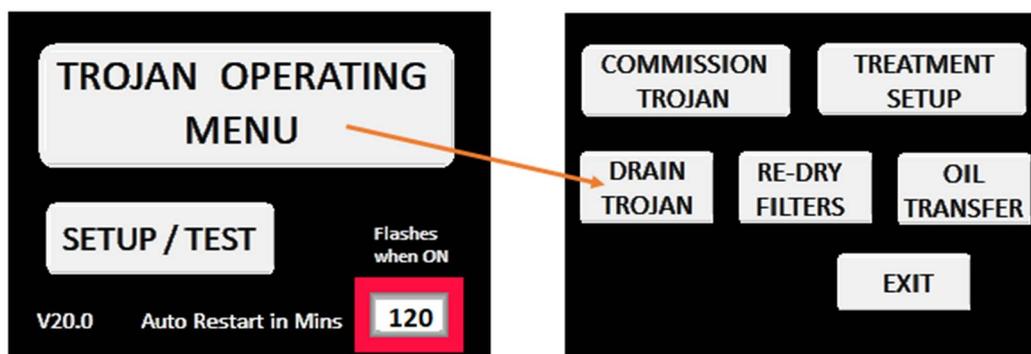
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- Into a drum – in this case close the valve on the transformer that the return hose is connected to, remove the return hose and flange from the transformer, bolt the flange together again and put it into the top of a drum.

Process

During the Drain cycle, it is very important to follow the instructions on the screen carefully. It will request the opening and closing valves. **Do not be distracted.**

From the Trojan "Home Page" select "Main Trojan Menu" which will take you to the screen below as displayed below.



Follow the instructions on the screens below carefully. The TDOS has an audible beeper that will sound when the screens shown below change during the Drain Cycle, and operator involvement is required.

During the drain process, P3 value (Pressure Sensor # 3) is displayed on the PLC screen. This will vary in pressure initially, but about 15 seconds after opening the Green Valve, it will settle to around 20 to 25 psi, depending on the height of the transformer. Vacuum Pump # 1 will come on during the drain cycle to suck the oil out of the filter tank into the buffer tank.

Drain screen Selection

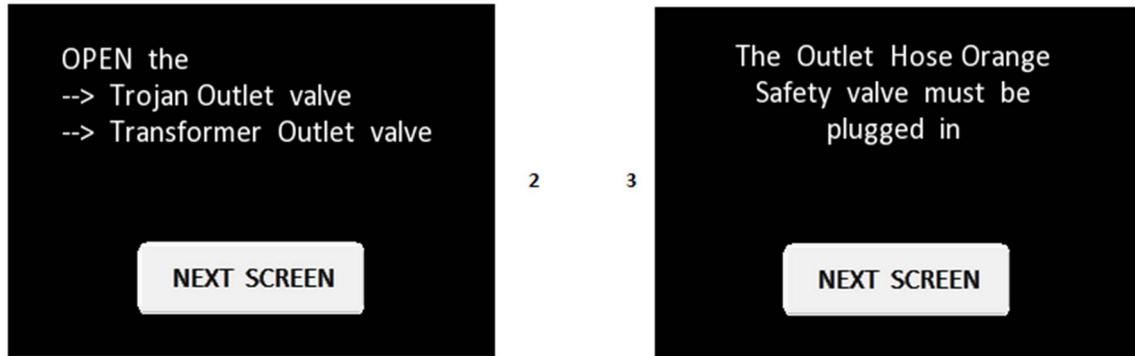
This screen confirms the process selected and about to be undertaken. Press "Next Screen" to proceed.



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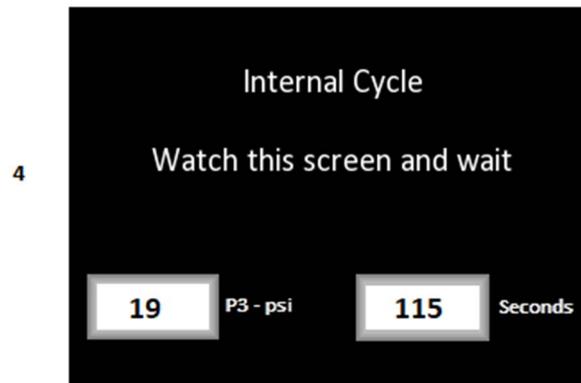
Drain screens # 2 to # 3



Follow the instructions on Screen # 2, then press "Next Screen".

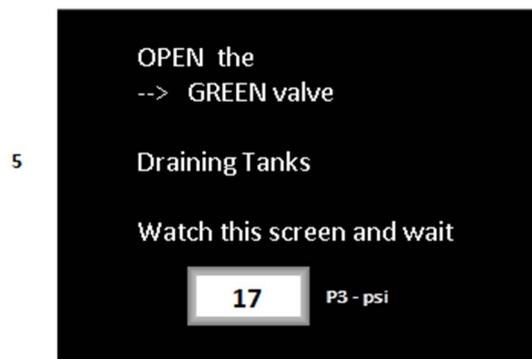
When Screen # 3 is displayed, confirm that the **Outlet** oil hose orange isolation valve is plugged in with the Amphenol cord connectors. Press "Next Screen".

Drain screen # 4



The Drain Process has now started. Watch the counter and wait for further instruction.

Drain screen # 5



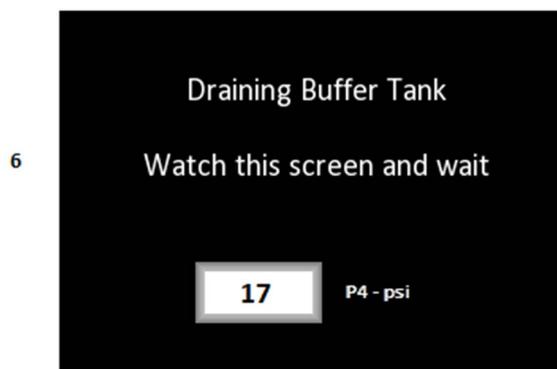
Open the Green valve when instructed (the buzzer will sound). This allows a controlled volume of air into the TDOS filter tank to allow the oil to flow out at the bottom and into the buffer tank.

The filter tank and vacuum chamber are being drained. Watch and wait for further instruction.

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Drain screen # 6



The buffer is now being drained. Watch and wait for further instruction.

Drain screen # 7 to # 10

The TDOS is drained. Follow the instructions displayed on the screens to prepare the TDOS for moving onto the next transformer.



Press "Exit" to return to the Home Page.
The TDOS can now be moved onto its next transformer.

11. Control Screen / HMI

Operator control of the TDOS is via the touch screen HMI. Simply touch an icon to go through the various processes.

The screen will switch "off" after 90 minutes and go blank. To switch it back on, simply touch the screen.

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12. Control Cabinet Switches

As well as the touch screen HMI, operation of the TDOS is conducted via various switches and a Stop Button located on the electrical cabinet.

The fascia (below) contains the following switches and buttons.



Pump Speed Control

This switch selects between the two (2) oil flow rates provided.

It is recommended to operate the TDOS at full speed.

Use the slower flow rate when operating on transformers / tanks with smaller oil volumes of less than 200% of the Trojan maximum flow rate.

Auto Restart

The TDOS has the capability to restart automatically after a power outage / fault alarm. This function is controlled via the **Auto Restart** switch on the electrical cabinet.

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The Auto restart switch will work as follows:

ON: After a power outage / fault alarm (certain faults only) the TDOS will start automatically in the filtering cycle when power is returned after 120 minutes. It is important to leave the switch in the OFF position during the Commissioning Cycle, or when setting up the Trojan in preparation for Commissioning, and then switch to "ON" when those tasks are completed.

OFF: When power is returned after a power outage, the TDOS will sit idle until an operator manually restarts the system.

The Auto Restart section below covers this function in greater detail.

Stop Button

Press this button to Stop the Trojan at any time.

Modem On / Off

This switch allows the operator to power cycle the modem. It is recommended to leave the modem powered **ON** at all times, even when there is no cellular signal.

If the modem is "Off", no data will be recorded in the eWON modem.

13. Auto Restart

When the Auto Restart switch is on, and the TDOS is in the "Home Screen", the Auto Restart alarm light on the HMI screen will Flash OFF and ON. This will alert the operator that the Auto Restart switch is in the ON position.

The Trojan will automatically "Restart" ONLY from the "Home Screen" – not from a fault screen.

Setting in Auto Restart

Turn the "Auto Restart" switch to the **OFF** position while setting up and commissioning the Trojan.

When the Trojan has been commissioned and put into the desired treatment program, turn the "Auto Restart" switch to the **ON** position.

If there is a power interruption to the Trojan, when the power reconnects the PLC will start up in the Home Screen, and the 2-hour counter will be activated. The Trojan will always restart in the Filtering Prep Cycle then move to the filtering cycle in the normal manner.

The Auto Restart will also take effect after most of the minor Fault / Alarm interruptions. The Trojan will record the Alarm number and time that it occurred, clear the Alarm, and then Restart after 120 minutes. These minor alarms are not threatening to the safety of the transformer. Any faults such as Sump level switch activated, Return hose loss of pressure, Vacuum line oil tank Full, etc will not be overridden, and the Trojan will stay in the Alarm state until cleared by the operator.

All Alarm events are recorded.

NB: You **do not** need to re-commission the TDOS before restarting in the Treatment Program unless the entire system has been drained of oil.

14. Restarting the TDOS After a Fault / Alarm

In the event of a fault, DO NOT drain the TDOS

Unless stipulated in the fault alarms.

If a fault alarm occurs during operation, the respective Fault will be displayed on the PLC touch screen. Depending on the type of fault, instructions may be provided on the screen on how to clear the fault to resume operation. Otherwise, refer to the list of Fault Alarms later in this manual or the list attached to the Cheat Sheets.

Once the fault is cleared, to restart the TDOS in the Treatment Program, simply go through the Treatment Program selection process covered above in Section 8.

The previous hours entered in the Cycles for Analysis and Degassing Vacuum Cycle will have been deleted from the PLC memory when the cycles were completed but check to confirm.

15. Topping Up the Transformer with Oil Using The TDOS

Oil can be added to the transformer using the TDOS 2nd Inlet Valve, which is located directly above the Trojan Inlet Valve.

NB: Oil cannot be added unless the TDOS has been commissioned to the transformer.

Stop the TDOS, and from the home screen select Treatment Cycle Selection. Enter zero hours for the Analysis Cycle. Oil can be added wither through the Degas Cycles or Water Removal Cycle.

Wait until the Prep Cycle (Degas or Filtering) has finished (10 minutes), and the TDOS is in the Degas or Filtering Cycle proper.

Process

- Connect a wire reinforced hose (non-collapsible) to the second Inlet Valve (1/2") and put the other end into oil tank / drum. Leave the Trojan inlet valve **open** and the 2nd inlet valve **closed**.
- When the treatment cycle proper starts, let it operate for a few minutes. Then to add oil to the conservator, **close** the Trojan Inlet valve on the TDOS, then immediately open the small red handled 2nd Inlet valve. This will draw oil from the oil drum into the Trojan and send it through the filters and into the transformer.
- Watch the transformer oil level to ensure it is not overfilled. When the oil is at the correct level, **close** the second Inlet Red valve and re-open the Trojan Inlet valve on the TDOS. The filtering cycle will continue as normal.
- Any oil sucked into the TDOS from the top up tank / drum will pass thru the filters, which will remove particles and dissolved water. Any air bubbles will be trapped inside the in the TDOS, and removed appropriately.
- Now remove the hose from the second inlet valve, replace and secure the safety cap.
- Clean up any oil you may have spilt in the bottom of the TDOS sump.

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16. Oil Pump

The oil pump fitted to the TDOS is a centrifugal type pump. It does not require any routine maintenance. It is controlled by a VSD unit, which has been pre-set at the factory. The rotational speed of the pump motor may alter during various cycles.

Brand: Grundfos
Model # CR5-6

17. Vacuum Pumps

Depending on the TDOS Model, either one (TDOS LV) or two (TDOS HV) vacuum pumps are fitted.



Vacuum pump # 1 (left photo)

This vacuum pump is fitted to all TDOS models. It is a Dry Type vacuum pump.

Brand: Gardner Denver
Model #: 2585-C-02

The TDOS is programmed **not** to start the vacuum pump if the vacuum pressure is below 850 mbar. If the vacuum pump is due to be activated, air will be allowed to enter the Trojan until the pressure rises which allows the pump to start.

This vacuum pump is used during:

- Commissioning, to remove all air from the system and hoses
- The Analysis, Degassing and Filter preparation cycles to evacuate any air / gasses
- During the filter Re-Dry process.

This pump requires no regular maintenance.

If the performance of the pump starts to fail and will not achieve a certain level of vacuum after a certain time period, Alarm screen # 4 will be activated and the TDOS will shut down. The most likely cause is the reed valve set at the top of the pump.

Vacuum pump # 2 (HV Model only) (right photo)

This is an oil filled rotary vane pump with a maximum pressure of 0.5 mbar absolute. It is used primarily during the degassing cycle.



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Brand: Busch
Model # R5 RA 0025

This vacuum pump requires periodic changing of the lubricating oil, exhaust pump filter, and oil filter. The oil level should be inspected whenever you are onsite, or as per the Maintenance Interval below.

Item: **Vac Pump # 2 Lubricating Oil**
Description: VM 68 Oil / 3 Phase Mineral (or similar)
Changeover: Change every 1000 hours of vacuum pump operation (in a clean application – no condensation in the pump oil). In a “dirty” application, this reduces to changeover every 500 hours of vacuum pump operation.

The oil can be sourced from any reputable oil supplier. In colder or hotter climates, an oil with a different viscosity is recommended. Contact Trojan or the pump manufacturer / distributor for further information.

Check the condition and colour of the oil through the sight inspection class on the side of the pump.

Vacuum Pump # 2 (Busch): Maintenance Schedule

Maintenance work	Interval	
	Normal application	Harsh application
<ul style="list-style-type: none"> Check the oil level, see Oil Level Inspection [▶ 17]. 	Daily	
<ul style="list-style-type: none"> Check the machine for oil leaks - in case of leaks have the machine repaired (contact Busch). In case an inlet filter is installed: <ul style="list-style-type: none"> Check the inlet filter cartridge, replace it if necessary. 	Monthly	
<ul style="list-style-type: none"> Change the oil*, the oil filter* (OF) and the exhaust filters (EF). 	Max. after 4000 hours, at the latest after 1 year	Max. after 2000 hours, at the latest after 6 months
<ul style="list-style-type: none"> Clean the machine from dust and dirt. In case of a gas ballast valve (GB) being installed: <ul style="list-style-type: none"> Clean the gas ballast valve. If the machine is equipped with an air-oil heat exchanger (AHE): <ul style="list-style-type: none"> Check and/or clean the air-oil heat exchanger. 	Every 6 months	
<ul style="list-style-type: none"> Contact Busch for an inspection. If required, overhaul the machine. 	Every 5 years	

* Service interval for synthetic oil, shorten the interval when using mineral oil, contact Busch Service

Use only the recommended oil and filters. Failure to change the oil and filters at recommended timelines may result in pump failure.

Refer to the Busch manual (provided via soft copy) for full descriptions & maintenance instructions.

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18. Vacuum Line Oil Collection Tank (VLT)

The vacuum line collection tanks act as a collection vessel for any oil and oil vapour that travels down the vacuum line hoses toward the vacuum pump/s, and to protect the vacuum pump/s from damage from oil ingress.

The tank has two small valves with **Red** handles that allow the draining of the vacuum line collection tank if the level switch is activated. The storage capacity is about 5 litres / 1.5 gallons. It is unusual for large amounts of oil to collect in this tank.

There is a level switch located at the same end as the bleed valve. If the oil level in the tank reaches the level switch it will shut the TDOS down and display the fault signal (Alarm # 17) on the HMI screen.



It is also good practice to check the tank on regular onsite inspections. Only open these valves if the TDOS is stopped.

Do not open the small red valves if the vacuum pump is operating.

Normally the tank should be drained prior to commissioning when attached to the transformer, and during site visits.

To drain the VLT, open the drain valve first and leave it open. This will let air into the tank. Then, gently open the drain valve (with the hose attached) to allow any oil to drain the oil into a small collection vessel, or the sump.

When drained close both valves and restart the TDOS in the required treatment cycle. No other maintenance is required on this tank apart from checking the tightness of the pipe work fittings from time to time.

19. Water in Oil Relative Humidity Sensor

The water in oil sensor used is an E+E 36. It measures the oil temperature, and the relative saturation of water in the oil. They normally give years of accurate service.

Two 4 – 20 ma outputs from the E+E to the PLC are:

- Temperature - scale 0 to 100C
- Relative Saturation scale 0 to 1. Shown on PLC screen as %.

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It is recommended that the sensor is checked for accuracy annually.

Brand: E+E Elektronik
Model #: EE364-T63EA/AwTx024M

20. Foam Level Control

During the HV degas cycle it is not unusual for significant amounts of foaming to occur in the TDOS degas chamber, to the extent where the whole tank is filled with foam. Any foaming is sensed by the optical foam level sensor, which are located at the canopy end of the vacuum chamber.

This foam level switch DOES NOT need adjusting and has been pre-set at the factory. The TDOS will automatically compensate for excessive foaming and self-regulate. There is no intervention, or setting adjustments required to be made by the operator.

Brand: Banner
Model #: QS18VP6FF100

21. Flow Switch

A flow switch is used to confirm oil flow through the system. If no flow is present, the system will shut down and a fault screen will be displayed in the HMI.

No regular maintenance is required.

Supplier: Thomas Products
Part #: 18101

22. Level Switch and Level Sensors

Four level sensors are used to control oil levels in the TDOS. These are located by the electrical connections for the heating elements.

No regular maintenance is required.

Supplier: SST Sensing (UK)
Part #: LLC710D324-004 P-type

In addition, the same type of optical level sensor is used on the vacuum line tank. It activates if liquid is present in the tank / trap.

No regular maintenance is required.

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23. Final Particulate Filter

Spin on type filters are used to remove particulate down to 1 micron.

Replace at regular intervals and watch for return line pressure increasing to assess particulate build up and replacement time.

Supplier: Hy-Pro Filters
Part #: HP75L8-1MB
Quantity: Two (2)

Take care when replacing the filter, as a quantity of oil may still be present in the filter – rags should be on hand for this task.

The best time to replace the filter elements is when the system is drained between use on transformers.

Loosen the filter element and then put a bucket or similar underneath. Then remove the filter by spinning counter clockwise.

When installing the new filter - ensuring the new, wide seal is in place in the alloy head, then smear some oil on the seal surface and on the mating part of the filter. This will allow you to tighten properly. If the filters are replaced after commissioning, simply restart in any of the three cycles that you require and during the preparation cycle the air, etc will be flushed out of the filter and expelled from the Trojan.

Once the TDOS is back in operation, check for any oil leaks around the top of the filter. Tighten again if necessary.

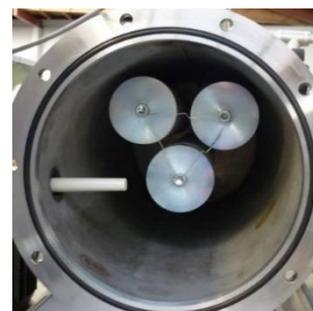
24. Degas Coalescing Elements

The TDOS uses degas coalescing elements to remove gases (& moisture) down to low levels. These elements are more effective than traditional spray technology, particularly at lower oil temperatures and create less foaming.

The elements are housed in the TDOS vacuum chamber.

Three (3) elements are used on the system.

Supplier: Compressor Filter Supply (USA)
Part #: D102300
Quantity: Three (3)



Filter life – Typically lifespan of the degas elements should be approximately 1 year (if used consistently).

To replace the filters, the TDOS should be drained, and power supply switched OFF.

Access to the tank is through the lid, which is secured by 10 nuts and bolts. When removing the lid, have rags underneath as some oil may be present.

Cut the lock wire and remove from the vacuum chamber. Then unbolt the cap screws holding the filters in place. Change one element at a time. Slide off the front spacer, remove the filter & dispose of properly – some oil will still be present in the filter, so have a suitable container handy to place them into.

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Insert the new filter, and replace the front spacer making sure the seal is in place and in good condition. Repeat the process for the remaining two (2) elements.

Tighten the cap screws, then insert new lock wire. Don't drop any small parts in the vacuum chamber.

Replace the O ring seal in the lid before replacing the lid. Check the condition of the O Ring. If damaged, replace it.

Then get the lid bolts finger tight and even, and then take care to start at the centre of the lid bolts and work out gradually both sides to ensure the lid is tightened up equally in a normal manner.

25. Changing the Water Removal Filters

The TDOS removes moisture from the oil and insulating cellulose via large capacity, adsorbent filters. These filters are automatically regenerated / redried by the TDOS, and require no regular maintenance

Brand: Trojan Dry Out Systems
Part #: Trojan 50
Quantity: Three (3)

Filter life – Typically the water removal filters will last 18 – 24 months before replacement is recommended. This is largely dependent on the amount of sludge and other particles they are exposed to.

When changing the filters, the TDOS must be drained, and the main power switched off.

The TDOS 1000 with has one filter tank, containing **three filters**. Access to the tank is through the access panel to the right of the front of the electrical cabinet.

Remove the cover and the end of the tank is obvious.

Remove the ten 8mm cap bolts and remove the lid. The filter retaining centre bolt and end support bracket will be obvious. Slacken off the 10 mm support bolts, cut the lock wires and unbolt the ¾ inch UNF centre bolt, and slide off the filters taking note of the spacers and oil seal washer positions. Replace in the same manner using the spacers in the same position. The filters should have a crush of about 12mm (½ inch) prior to tightening the centre bolt. Replace the lock wires, adjust and lock the support bolts / bracket and replace the O ring seal before replacing the lid. Get the lid bolts finger tight and even, and then take care to start at the centre of the lid bolts and work out gradually both sides to ensure the

lid is tightened up equally in a normal manner. Place the used filter in a plastic bag or similar and dispose of in the appropriate manner.

Full instructions come with each set of new filters.

If in doubt about whether the filters need to be replaced or not, please contact Trojan for advice. (contactus@dryoutsystems.com).

26. Water Removal Filters – Redrying New Filters Prior to Use

When the large adsorbent water removal Filters are replaced with new ones, they will need to be Re-Dried prior to use.

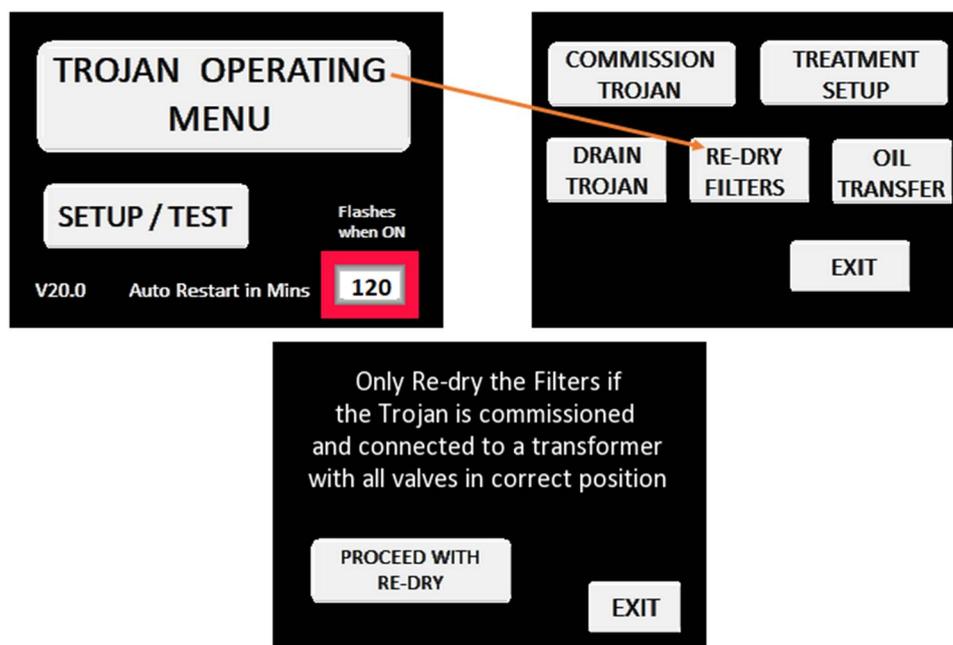
This process does not need to be undertaken with the original set of filters supplied in the TDOS – these have been redried during testing at Trojan's factory.

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Once the new water removal filters have been installed, following the instructions below:

1. The TDOS must be connected and commissioned to a transformer or large oil tank and made ready for normal treatment cycle operation by commissioning the TDOS as per normal setup described previously in this Manual.
2. Once commissioned (full of oil), using the HMI, select "Re-Dry Filters" from the Trojan Operating Menu.



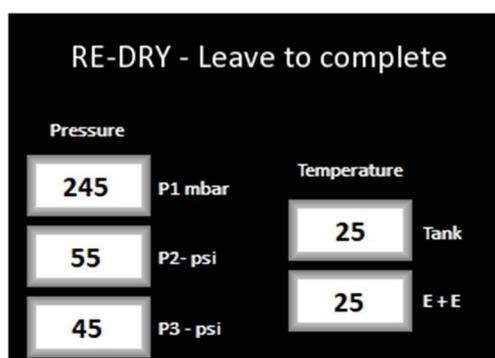
3. This will start the process of Re-Drying the filters. The TDOS can now be left to undertake this process.

The Filters will be automatically regenerated (Re—Dried) to the required level.

This ensures that any water in the filter above the accepted level will be removed and make the filtering cycle more effective.

During the Redry process, screens similar to that shown below will occur.

Do not stop the TDOS during the Redry process unless absolutely necessary.



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4. Following the Filter Re-Dry Cycle, the TDOS will automatically move to the "Water Removal Cycle" and start filtering the oil in the transformer or oil tank system. Make sure that the correct filtering cycle hours have previously been entered into the Treatment Program.

To check these values, from the Home Page screen select Main Trojan Menu → Treatment Setup and go through the Treatment Cycle Setup as described in the previous pages above.

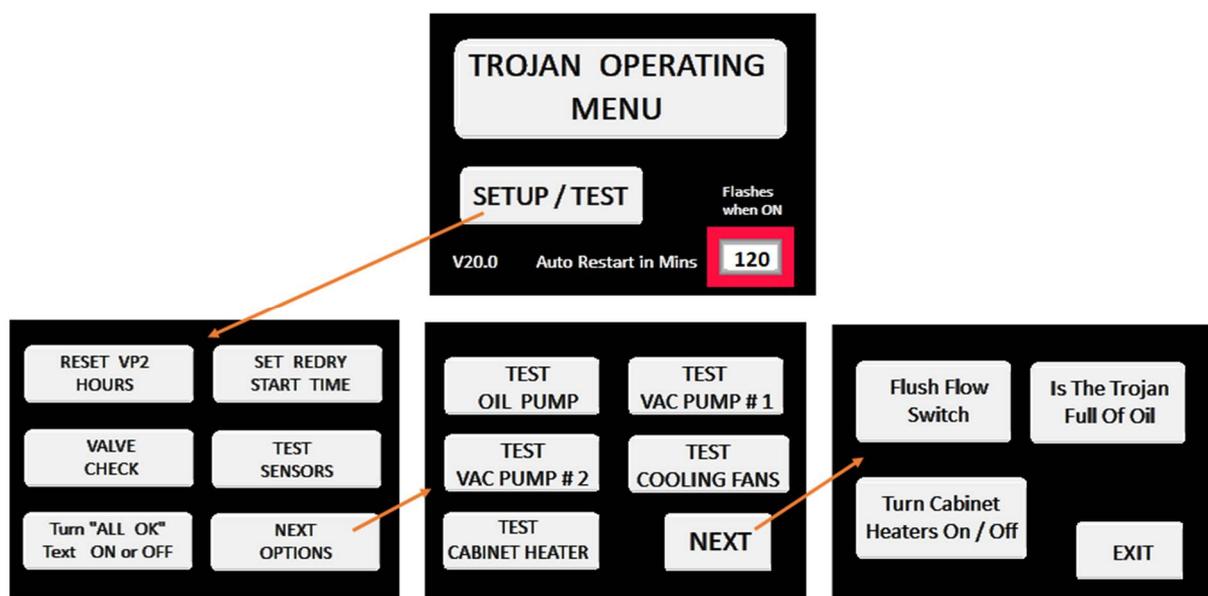
Immediately after setting these up, press the stop button and return to the home page, then go into the Re-Dry Filters selection.

27. Setup / Test Options

The operator has the capability to test various components on the TDOS, as well as set the desired parameters for certain functions.

These are described in detail below.

To access these options, from the main home page screen – select "Set up / Test" to reach the first screen. Further options are available by selecting "Next Options" to reach the second screen.



Reset Vacuum Pump # 2 (VP2) Hours

To ensure that regular maintenance requirements are maintained for Vacuum Pump # 2, a counter has been installed on the TDOS PLC which counts the hours of operation of the pump.

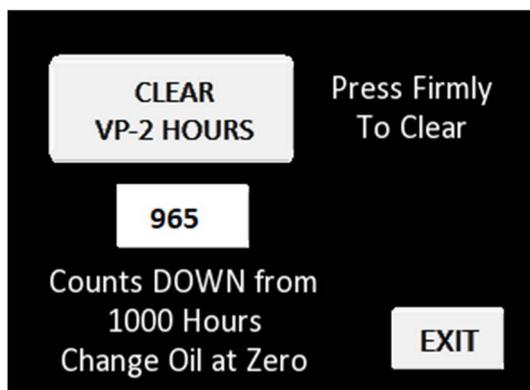
The timer counts down from 1000 hours. Check the condition of the oil and other consumables (as per list above) at that period.

To reset the time, press "Clear VP-2 Hours" for a few seconds.

The timer will reset to 1,000 hours.

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Set Filter Redry Start Time

The Filter Re-Dry start time is pre-set in the factory to occur at 5am (on the 36 hour cycle the Re-dry starts at 5am then at 5pm on the alternate cycle, then back to 5 am etc).

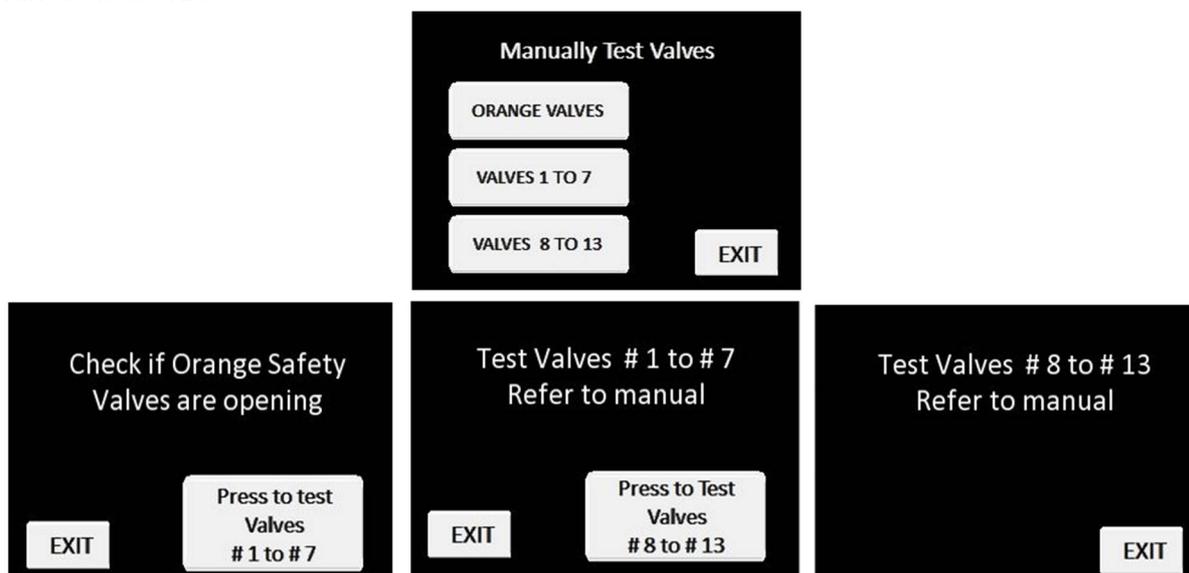
To alter the time at which the Re-Dry cycle commences, from the home page select "Trojan Set Up Options", then select the "Set Re-Dry start time" button. Set the desired time with the touch screens in 24hr time format. When completed, press "Exit" to go back to the Home page.

Setting the Filter Re-Dry start time takes advantage of the load reduction and cool down.

Set the redry time to finish about an hour before the load / temperature starts to increase during the daily cycle.

Valve Check

This will allow the operator to check the operation of the orange isolation safety valves, and the solenoid valves on the TDOS.



Orange Safety Valve: When checking that the Orange Safety Valve opens, watch for the pointer to change position from "Closed" to "Open".

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Solenoid Valves: When "Valves 1 to 7" is selected, power will be supplied to the solenoid valves on the TDOS to open them.

Firstly, check the small LED green lights on all the 6 amp relays in the electrical cabinet are illuminated.

Then check the ends of the solenoid valves by touching a steel ruler or metal screwdriver to the retaining nut. There will be a minor magnetic pull on the ruler. If there is no magnetic pull, check the power supply to the individual valve.

Run the same test for valves 8 thru 13.

The solenoid valves used are manufactured by Burkert. A selection of 3/8"; 1/2" and 3/4" are used.

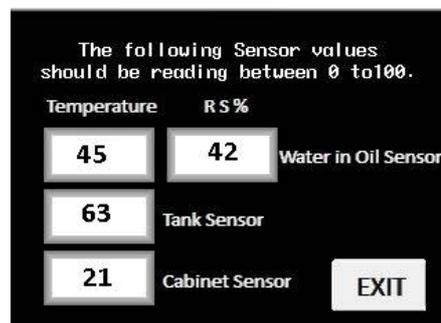
If valves need to be replaced, check that the correctly sized diaphragm of coil is being used.



Test Sensors

BY selecting "Test Sensors", a screen will come up and display the readings from the E+E water in oil sensor (Temperature; RS%); the thermostat in the tank; and the thermostat on top of the electrical cabinet.

Look for any abnormal readings, of non-numerical values.



Turn "All OK" email On or OFF

If turned to ON, the TDOS will send an "All OK" email message at a pre-set time each day if the system is operating in one of the Treatment Cycles, or in the Filter Redry Cycle.

If a message is not sent, the system is either: in a fault screen; is sitting in the Home Screen; or is without power.

The "All OK" message is a simple method of confirming that the system is operating as expected. If no message is sent, then the reason needs to be investigated.

If this message is turned OFF, no message will be sent daily.

When the "Turn "ALL OK" message ON or OFF button is selected, the left-hand screen below will appear.

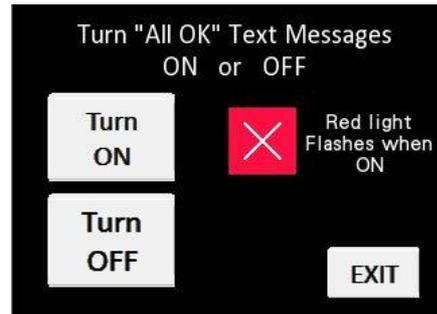
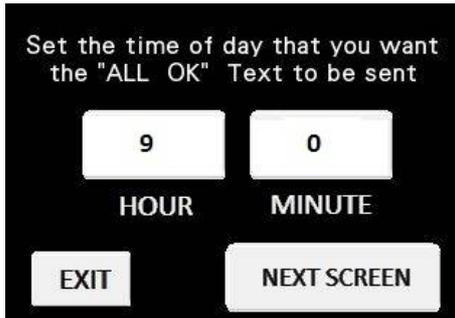
Confirm the time of day the email will be sent – perhaps an hour or two after the workday has started? Then press "Next Screen", which will take you to the right-hand screen below.

Press "Turn ON" to activate the daily message being sent – the red light will flash when this is activated ON.

Select "Turn OFF" to deactivate the daily message being sent.

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Test Oil Pump

When this button is selected, the oil pump will start and run for a few seconds. Check the rotation of the pump (directional arrows are on the top of the pump).

If the pump does not start, check:

- Check the circuit breaker. Is power coming in at the top and bottom?
- Is the VSD is operational? Is it in fault mode? What is the voltage to the VSD?
- Check the wiring terminals, and connections 103.05, 103.06 and 103.07 on the PLC.

Test Vacuum Pump #1

When selected, Vacuum Pump # 1 will start and run for a few seconds.

If the pump does not start, check:

- Check the circuit breaker. Is power coming in at the top and bottom?
- Is the plug plugged in?
- Is the switch on the pump "up"?

Test Vacuum Pump #2 (HV Model Only)

When selected, Vacuum Pump # 2 will start and run for a few seconds.

If the pump does not start, check:

- Check the circuit breaker. Is power coming in at the top and bottom?
- Is the VSD is operational? Is it in fault mode? What is the voltage to the VSD?
- Check the wiring terminals, and connections 102.02 on the PLC.

Test Cooling Fan

The cooling fan will start and run for a few seconds. Check that it is blowing air into the TDOS canopy.

If the fan does not start, check:

- Check the Omron 6amp relay

Test Cabinet Heaters (Heating Fans - optional item only)

If fitted as part of the cold weather kit, the heating fans fan will start and run for a few seconds. Check that it is blowing air into the TDOS canopy.

If the fans do not start, check:

- Check the Omron 10amp relay

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- Check the main MCB
- Is the "Turn Cabinet Heaters On / Off) function set to "On"?

Flush Flow Switch

It may be necessary to flush the Thomas flow switch if repeated Flow Switch alarms occur. This may be because swarf / debris is caught under the plunger in the flow switch.

Trojan will provide guidance on this issue and provide a separate document on how to flush the flow switch.

Is the Trojan Full of Oil

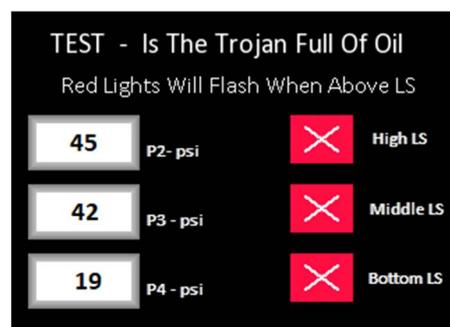
This feature has been included so that Operators can confirm there is No Oil in the TDOS prior to commissioning the unit to a Transformer.

The Trojan does Not have to be connected to an oil supply to perform this test.

Select "Is the Trojan Full of Oil" and the screen on the right will appear. Confirm the valve positions, then press "Next".

The oil pump will start and run for a short period of time. Red lights will flash for the corresponding level sensor if oil is above that level sensor in the Buffer Tank.

If oil is present above any level sensor, the Drain process will need to be undertaken prior to attempting to commission the TDOS to the Transformer.



28. Temperature Transmitter – Filter Tank

The temperature transmitter is located under the cover where the water removal filters are accessed. Remove the end panel and it will be visible

The Temperature sensor probe is 4-20 ma and is used to confirm oil temperature.

29. Heating Elements

The heating elements are used only during the filter regeneration cycle. They are located on the left-hand side, when looking at the electrical cabinet. A stainless-steel cover is used to cover the ends of the heating elements for protective purposes.

Remove the two nuts at the top of this cover and the element and level switches will be visible. There are two elements used, with each 230V, 2250w.

When checking the tightness of the nuts holding the wires on the end of the element, use two small spanners with great care. Failure to use two spanners will twist the end off of the element.

30. Remote Communications Modem / Data Download

The TDOS includes a web based, remote communications modem, which enables the operator to perform the following functions remotely once the data enabled sim card is inserted (not supplied by Trojan):

- Download operating data
- Start / Stop the TDOS
- Change the treatment cycle selection
- View the real-time readings

Please refer to the separate Trojan Data Downloader Manual for full description on modem setup and operation.

Note: To collect and store data, the modem must be switched "ON".

If power to the modem is switched "OFF", data will **not be** stored in the modem, and will not be available for download.

31. Fault Input / Output - Optional

A 24-volt output fault signal may be provided for the Scada inputs & outputs.

A five (5) pin amphenol plug (male and female connections are included) is supplied to enable the TDOS to send and receive digital signals.

The amphenol plug from the Trojan PLC is supplied pre-wired. Use the spare amphenol plug provided to complete your wiring to the designation noted below.

User Fault Input - such as a fault supply from the transformer (i.e. conservator level switch). This would shut down the TDOS: close the isolation safety valves and make safe.

Plug terminals #1 and #2

Connect **your separate** 24vdc to terminal #1

Connect **your separate** 0vdc to terminal #2

This will send switch a 24vdc relay and send 24vdc from the TDOS power supply to the PLC and stop the TDOS.

On the HMI, the screen will display "Alarm Screen # 32: User Fault"

At the same time an output fault will be transmitted through the following.

Test this operation by initiating simulating the fault by putting 24vdc on the #1 terminal

Trojan Fault Output

Plug terminals #3 and the #N

Connect **your separately sourced** 24vdc into terminal #3 and when a Fault is activated by the Trojan, the 24vdc will be supplied out of terminal #N to create a SCADA alarm.

Connect the wire from #N terminal to your SCADA system.

Test this operation by holding up the sump level switch for 5 seconds to create an alarm.

This alarm will alert the user that the TDOS has had a Fault.

32. Fault Messages and Fault Screens

In the event of a fault alarm, you DO NOT need to drain the TDOS
Unless stipulated as an instruction on the PLC screen

The TDOS has a number of interlocked safety cut-outs / alarms in place to protect the TDOS, the Transformer and Operators.

When a fault occurs, the TDOS will shut down automatically. Any pumps operating will stop, and the isolation safety valves will close.

The relevant fault alarm – with description of the fault – will be displayed on the HMI screen, as well as being emailed to any the listed Operators.

The web HMI will also display the fault, and a full description of the fault can be viewed on a separate tab on the web HMI.

In most cases the TDOS can be restarted manually, remotely or automatically (if the switch is in the “On” position).

Unless stipulated on the HMI screen (or fault description), there is no need to drain the TDOS of oil to clear the fault.

A full list of Alarm descriptions is provided in the TDOS Cheat Sheets which accompany this Operating Manual.

Fault notification.

Any faults should be communicated to Trojan Dry-Out Systems immediately for our interest. Either telephone on ++64 3 365 5533, or email us at contactus@dryoutsystems.com

33. General Maintenance

Apart from checking that all connections both electrical, oil and hose fittings from time to time there is no real regular routine maintenance that is required apart from:

- draining the Vacuum line oil collection tank, and
- checking the oil quality and oil filter of the High Vacuum pump (HV model only)

Refer to the TDOS Maintenance Schedule for other suggested and routine maintenance requirements.

The Trojan is a high-performance system designed for removing water from oil in fine quantities. Make sure you drain all sludge and free water from the transformer before connection.

Treat and handle it with care at all times.