1. General instruction

A distinguishing feature of GE Jenbacher TSA systems is their low-maintenance design. However, they still require inspection and maintenance to ensure their safe and successful operation and to be able to preserve warranty rights. Intervals for these operations are specified in Section 2 of the maintenance work, which must be observed. Shorter intervals specified elsewhere must also be observed in addition, where appropriate. For components out of GE Jenbacher's scope of supply, such as the oxygen sensor, flare and condensate system, the relevant manufacturer's instructions must be observed.

All applicable statutory safety regulations and the safety instructions must be observed during all work carried out on the system. Work may only be carried out by specialist staff having relevant electrical and mechanical training. They must also be familiar with the hazards posed by gas-carrying components and wear the personal protective equipment provided. Electrical inspections should be carried out by skilled electricians to IEC 60050-826. For work which may only be carried out when the system has been made safe, the system must be shut down as specified in TI 1100-0106 and must be prevented from unexpected start-up.

2. Inspection and maintenance intervals

Maintenance work	Point	Interval		
		daily	monthly	two-yearly*)
Inspection round	3.	■		
Operating data log	3.	■		
Air filter	4.		■	
Cooling air	5.		■	
Condensate system	6.		■	
Flare	7.		■	
System operation	8.		■	
Carbon change	9.	as required (gas quality, system configuration)		
Protective-conductor connection	10.			■ *)
Heat-conductor resistance	11.			■ *)
Option Ex	12.			■ *)

***) Unless shorter intervals are specified elsewhere, we recommend that you carry out this work each time the activated carbon is changed.**

All inspection and maintenance work must be carried out at the specified intervals and logged in the inspection/maintenance log. The operating data log must be filled in each day.

3. Daily inspection round

The entire TSA system must be inspected during the daily inspection round. The inspection and any deviation of the system from its proper condition, including any measures taken to rectify this, must be recorded in the inspection/maintenance log. The operating data log must also be filled in. It is recommended that the inspection round and data recording are always performed at the same time of day. The data for the operating data log can be read off the screen on the TSA control cabinet or from the engine control cabinets. The possible entries for adsorber status are:
A – Adsorption, D – Desorption, S – Standby and N – Not ready.

The TSA is generally running while the daily inspection round is in progress. It must therefore be assumed that the system is under pressure, its surfaces are hot and system components (e.g. valves, fans) are likely to start moving (refer to the safety instructions).

The TSA system must be subjected to a visual inspection. If the system deviates from its proper condition, the causes must be found and any fault rectified in accordance with the instructions for working on the system. If you cannot find the cause, contact the GE Jenbacher customer service department. The above-mentioned deviations include:

- damaged components such as insulation and cables
- perceptible gas leak (smell of gas, sound of leak): The location of the leak can be detected using leak spray, a paper strip (is blown away) or with your hand. Warning: the smell of gas cleaned by the TSA is much reduced!

- function compromised, e.g. by dirt and formation of condensate in terminal boxes, failure of trace heating systems, leaks in the compressed air supply
- perceptible leakage of condensate (smell of condensate, signs of leak)

The condensate separator on the TSA compressed air supply unit must be opened each day to be emptied and then closed again.

Functional components from other manufacturers, such as valves, drives and controllers must also be subjected to a visual inspection.

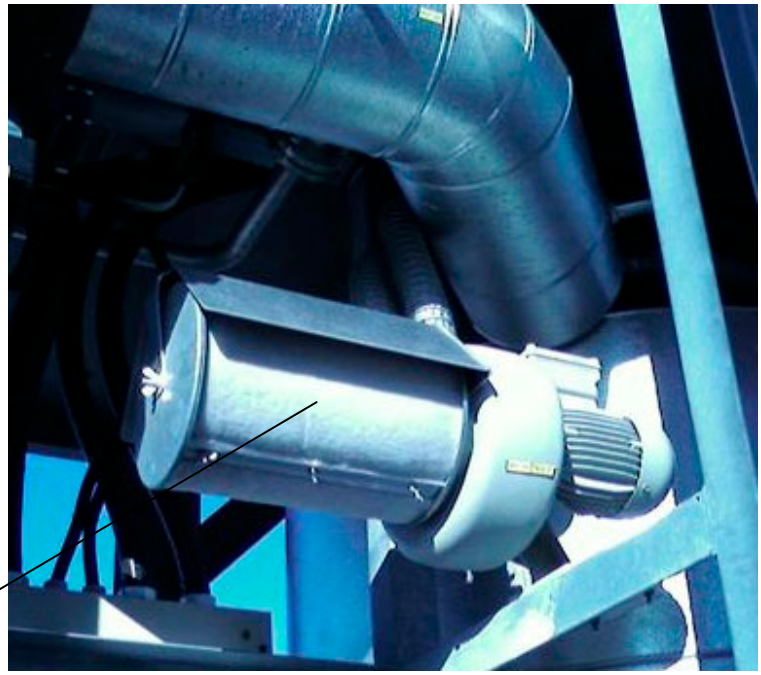
The device supplied by the customer to measure oxygen must be subjected to a daily visual inspection and calibrated and maintained in accordance with manufacturer's specifications.

4. Air filters

Check that the air filters of the cooling air fans are operating properly. First ensure that the air filter cannot be operated (the system must be in standby in automatic mode or shut down). After loosening the holder, check the filter, particularly on the inside, for mechanical damage and dirt (visual inspection). Change the filter if it is damaged or contains dirt which cannot be removed. Plain dirt can usually be removed by washing the filter out in clean water and then drying it. Attention: the fan may not be operated without a filter!

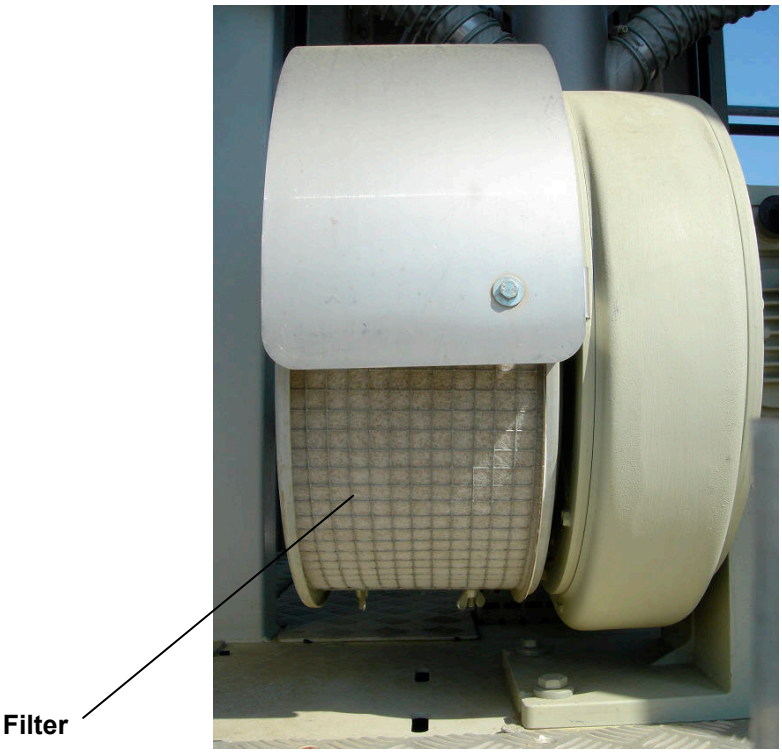
TSA Compact:

1 filter per vessel below the upper gas line



TSA Module:

1 filter per adsorber module centrally positioned



5. Cooling air

Check the operation of the fans during the cool-down phase with the fans running. First carry out a visual inspection to check that the cooling air is entering the fans freely and being expelled freely into the top corners of the module frame. Warning: the expelled air may be at high temperatures! Next test the cooling air to check for the formation of an explosive mixture. Use a suitable portable gas detector, which you have calibrated in accordance with the manufacturer's instructions before the inspection, to detect explosive mixtures. Check the air drawn in close to the fans as well as the expelled cooling air at all inlet and outlet points. Record the results of the inspection in the inspection/maintenance log.

6. Removal of condensate

Note: the condensate system is not part of GE Jenbacher's scope of supply!

The entire condensate system from the vessels and pipework to the collecting tank must be checked for deviations from the regular condition of the system. You should check for malfunctions, damage and dirt as well as gas and condensate leaks (refer to 3. Daily inspection round). In particular, components such as knock-out pots, intermediate and collecting tanks, ball valves and fill-level sensors must be carefully inspected. You should also follow the instructions of the manufacturers of these components.
Note the fill level of the collecting tank and discharge the condensate as appropriate in accordance with all applicable regulations.

7. Flare and flame arrester

Note: the flare including the flame arrester is not part of GE Jenbacher's scope of supply!

Test and maintain the flare in accordance with the manufacturer's instructions. You should also perform an additional monthly visual inspection. As it is essential to flush the vessels properly to ensure the operation of the TSA, check the flow of the FI 501 carrier gas together with the vessel pressure on the desorption side on Trending (for details, refer to the DIA.NE WIN TSA user manual). Check a few values at the beginning of the desorption process. Attention: only values from the periods between the flushes are meaningful, i.e. zero at flush gas flow rate FI 301. If you notice an increase in pressure from desorption to desorption with the carrier gas flow remaining the same or even decreasing, it can be assumed that this is due to a narrowing of the cross-section. The cause is often a partial clogging of the flame arrester in the flare. It should therefore be removed and cleaned as required. To do so, shut down the TSA as described in Technical Instruction TI 1100-0106 and prevent it from unexpected start-up. Next, the removal and cleaning must be carried out by suitably trained and equipped staff. Their equipment should consist of: gas detector, safety boots, protective suit, safety goggles, respiratory mask and chemical-resistant gloves. The actual cleaning must be done in the open air, observing the wind direction, in such a way that the deposits removed can be collected and disposed of properly. From the start of the process of removing the flame arrester until it is refitted, special care should be taken that no-one is in the immediate vicinity of the flame arrester and the flare.

8. System operation

The TSA system must be inspected once a month to ensure that it is operating properly. First find out whether its operation has been interrupted (during desorption) during the period under review. You can ascertain this from the Operational Data Log and the History of Alarm Messages (for details, see the DIA.NE WIN TSA User Manual). Then check the oil analyses during the period under review for all the engines whose fuel gas is cleaned by the TSA. The main information to be ascertained is the silicon content of the lube oil during this period. If there has been a significant increase, you must find out the reason for it. If you can rule out operational interruptions of the TSA and the engines operating in bypass to any noticeable extent, another possible reason is that the activated carbon used can no longer perform the TSA and must be changed. This is often the case where a system has been in operation for between six months and two years. As well as sampling the oil, you can also use other parameters such as gas samples to assess the condition of the activated carbon. If you have any other questions, please contact the GEJenbacher customer service department.

9. Activated carbon change

Note: to determine when the activated carbon should be changed, see also 8. System operation

Note: refer to Point 9.9 for instructions on changing the activated carbon

Warning: use only types of activated carbon which have been approved by GEJenbacher to fill the vessels!

9.1 Warnings

All applicable statutory safety regulations and the safety instructions must be observed during all work carried out while changing the activated carbon. This work may only be carried out by specialist staff having relevant electrical and mechanical training. They must also be familiar with the hazards posed by gas-carrying components and the use of inert gas and wear the personal protective equipment provided. The system must be shut down as specified in TI 1100-0106 and prevented from unexpected start-up during the removal of the used activated carbon and subsequent refilling. Please pay particular attention to the following additional dangers involved in changing the activated carbon:

- Danger of falling
- Working with suspended loads
- Inhaling gases (inert gas, landfill gas)
- Inhaling activated carbon dust
- Danger of explosion

You should therefore use the following personal protective equipment: gas detector, safety boots, protective suit, safety goggles, respiratory mask, hard hat, leather gloves and harness with safety lanyard.

9.2 Preparation work

The preparation stage requires:

GEJenbacher service technician

The TSA has to be operated in manual mode to allow the activated carbon to be changed. This requires a GEJenbacher service technician to be present.

Inertization

The TSA system must be inerted with nitrogen before the flanges are opened. Sufficient quantities must therefore be provided (requirement: approx. 15m³ per vessel). To save time when inerting it is useful to connect with a line of a suitable diameter (pressure regulator, etc.). To check whether the inerting operation has been successful, you need a gas detector to detect explosive mixtures.

Removal, transport, disposal

A suction device is required to remove the activated carbon from the vessels. This is usually done by a suction vehicle, which is also used to transport the activated carbon which has been removed. The spent activated carbon must be disposed of in accordance with all applicable legislation and regulations.

Refilling

A sufficient quantity of GEJenbacher-approved activated carbon must be available to refill the vessels. You must therefore take the delivery period into account, which can be several months. Each vessel requires approximately 1,200 kg. A suitable lifting device is required as the activated carbon is filled into the vessels from above.

9.3 Preparing the system

The TSA system must be showing temperatures lower than 100°C at all measuring points before work on changing the activated carbon begins. In systems in which it is permissible to operate engines without TSA and possible to operate them via a system bypass, the bypass must be opened and the TSA separated from the landfill gas flow by the shut-off devices. In all other cases, the engines in the system must be shut down as specified in TI 1100-0105 and prevented from unexpected start-up. The shut-off device upstream of the TSA must be closed. The TSA is then depressurised by the GEJenbacher service technician in manual mode.

9.4 Inertization

To inert the system, it is flushed with nitrogen at alternating pressures and this operation is repeated at least five times. The system is then checked using a suitable gas detector to rule out the presence of any explosive mixture, i.e. the methane content is less than 5%. A record must be made of the check and its result. The system must then be shut down as specified in TI 1100-0106 and prevented from unexpected start-up.

9.5 Removing the spent activated carbon

Once the top flange has been opened, the suction device including collection container is connected electrically to the module and earthed. The activated carbon is then sucked out from below. To ensure that the vessels are completely empty, the suction operation is then completed under visual observation from above.

9.6 Refilling with new activated carbon

Before refilling begins, the interior of the empty vessel is subjected to a thorough visual inspection. The opening of the top gas pipe is then sealed to prevent dust and carbon particles from entering the gas pipe. The activated carbon is filled using the filling funnel supplied and spread over the surface. The activated carbon fill level should extend about 5 cm above the top of the ribs of the heating tubes after being evened out by the discharge cone. The top gas pipe is then opened again and the front flange tightened.

9.7 Additional work

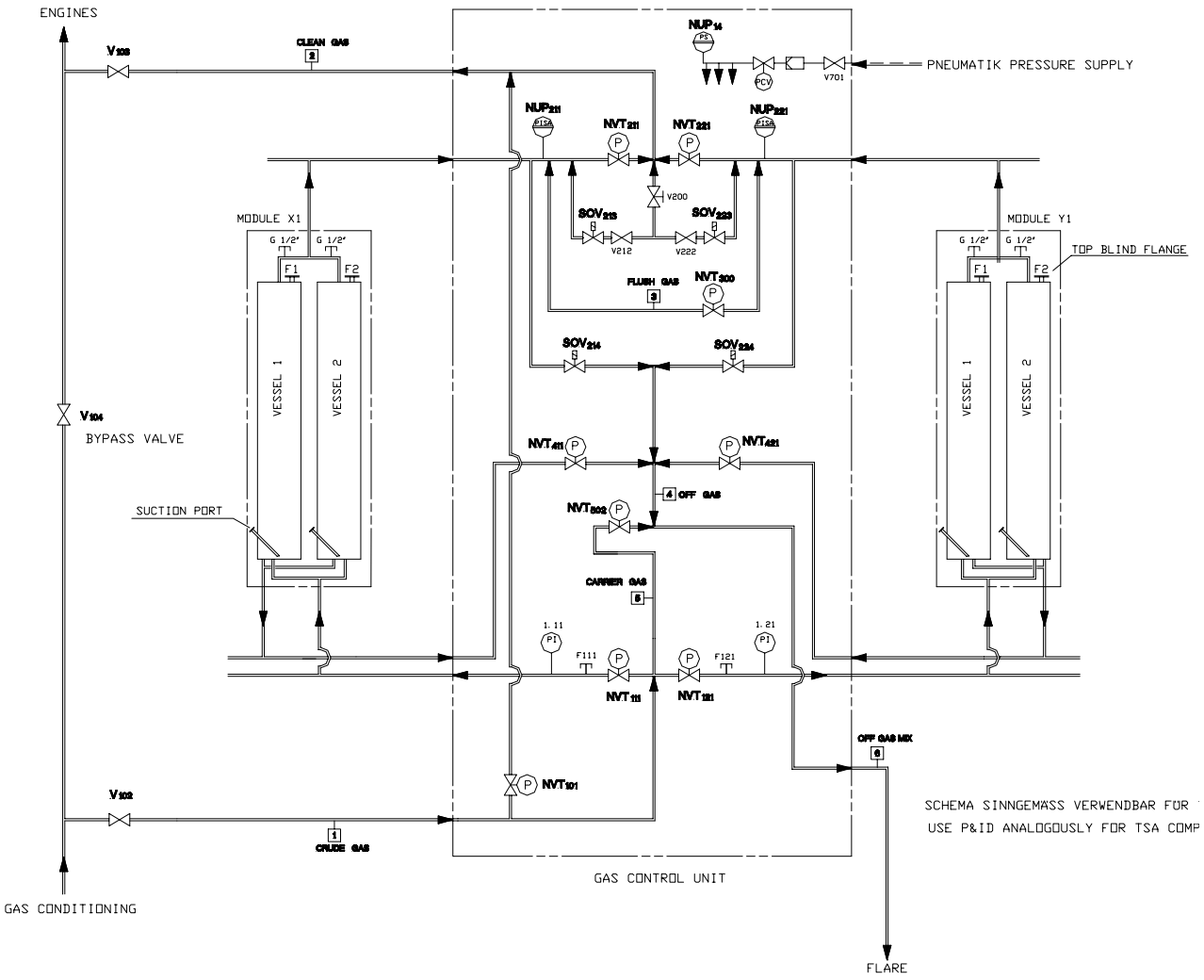
After the vessels are closed it is still possible to work on the TSA system as it has been made safe and can also be regarded as being filled with air. GEJenbacher recommends that all maintenance work should be carried out at this point, in particular the work referred to in Sections 7. Flame arrester, 10. Protective-conductor connection, 11. Heat-conductor resistance and, where appropriate, 12. Option Ex.

9.8 Restoring the system to operating condition

Finally, the TSA is restored to operating condition. First, the compressed air supply is started. Next, the landfill gas supply to the TSA is opened and the TSA switched back to manual mode once system pressure has been reached. The flare is started and the TSA is flushed with landfill gas towards the flare until the oxygen content has fallen to the permissible level for the TSA. After a final inspection to ensure that the TSA is gas-tight and in proper operating condition, the system can be re-started in accordance with "Starting – Operating – Stopping TSA". The TSA must be initialised after the activated carbon has been changed and before the switchover to automatic mode.

9.9 Instructions for changing the activated carbon

Diagram changing the activated carbon:



Preparation:

Step		Remarks
1	Open bypass valve 104 **or** shut down engines as described in TI 1100-0106	Danger of falling, depending on available space, use access equipment Personal protective equipment: safety goggles, safety boots, leather gloves
2	Close inlet valve 102 **or** close the shut-off device upstream of the TSA	
3	Close outlet valve 103	
4	Apply LOTO (Lockout/Tagout) on valves 102 and 103 **or** Apply LOTO on shut-off devices and engines	
5	Switch TSA to manual mode and open valves NVT 411 and NVT 421 while in manual mode	Reduce pressure to flare Personal protective equipment: safety goggles, safety boots, leather gloves
6	Switch on flare at flare control unit	
7	Have vessels depressurised	
8	Check vessel pressure; NUP 211 and NUP 221 must be less than 5 mbar	
9	Close valves NVT 411 and NVT 421	

Inertization:

Step		Remarks
10	Connect nitrogen tank to port F111 (F112) via pressure regulator; F111 (F112) is located next to NVT 111 (NVT 112) on the control unit Note: the details in brackets refer to the Y side which must be inerted in the same way on completion of the inerting of the X side	Carry out alternating-pressure flushing to eliminate explosive gas mixtures, i.e. to reduce methane content to below 5% Reduce pressure using flare Personal protective equipment: safety goggles, safety boots, leather gloves
11	Remove cover for control valve drive NVT 502 from the control unit and set to fully open while in manual mode	
12	Close ball valves V212 and V222 at the control unit	
13	Open nitrogen supply until vessel pressure PI 1.11 (PI 1.21) has reached 500 mbar and close nitrogen supply	
14	Open valve manually directly at valve drive NVT 211 (NVT 221), release pressure to below 5 mbar and close NVT 211 (NVT 221) in the same way	
15	Repeat steps 13 and 14 (at least five times)	
16	Use suitable measuring equipment to check all vessels of the flushed side individually for the presence of explosive gas mixtures or determine methane content using a ½" connection port on the top main pipe to the vessel, and record the results	
17	Repeat nitrogen flushing on Y side, steps 10 to 16; the	

	details in brackets apply	
18	Close control valve drive NVT 502, set to automatic mode and replace cover	
19	Switch off flare at flare control unit	
20	Shut down TSA as described in TI 1100-0106 and apply LOTO	

Removing the spent activated carbon:

Step		Remarks
21	Place ladder against roof of adsorber module and secure	Use suitable ladder and fixings, assistance required to secure ladder, danger of falling, observe wind direction Personal protective equipment: safety goggles, safety boots, leather gloves, hard hat, fall harness with safety lanyard, respiratory mask, protective suit
22	Open lid in roof of adsorber module, remove insulation hat and open top flange Note: if removed carefully, it may be possible to re-use the gaskets in some cases	
23	Open suction flange at bottom of vessels and connect suction device	
24	Connect module to suction device and collection container electrically and earth Warning: the extraction of the activated carbon can result in electrostatic charges!	
25	Extract activated carbon, assisting process by stirring from above and extract any residues from above until completely empty	
26	GEJenbacher service technician/supervisor to check that the vessels are completely empty and for any changes and damage to the entire visible interior using suitable light source. A record must be made of the check and its result. Warning: don't drop any objects into the vessel!	
27	Repeat process for all vessels, steps 21 to 26	
28	Close all suction flanges at bottom of containers	

Refilling with new activated carbon:

Step		Remarks
29	Plug the opening for the top gas pipe inside the vessel to keep dust and carbon particles out of the pipe	Use suitable ladder and fixings, assistance required to secure ladder, danger of falling, observe wind direction, danger due to working with suspended loads Personal protective equipment: safety goggles, safety boots, leather gloves, hard hat, fall harness with safety lanyard, respiratory mask,
30	Refill with new activated carbon using the filling funnel supplied until specified level is reached	
31	Carefully level the activated carbon discharge cone with a piece of wood; correct fill level: with the surface of the activated carbon level, it reaches to the transition from the cylindrical vessel wall to the dished end	
32	Remove plugs from top gas pipe	
33	Seal top flange; the use of new gaskets is recommended	

34	Repeat process for all vessels, steps 29 to 33	protective suit
35	Check all flanges, ports and fittings to ensure that they have been sealed with the proper gasket	

Additional work:

Step		Remarks
36	Carry out all work that requires the system to be made safe. GEJenbacher recommends that all maintenance work, especially on flame arrester, protective-conductor, heat-conductor resistance	

Restoring the system to operating condition:

Step		Remarks
37	Restore compressed air supply by opening valve V701	Personal protective equipment: safety goggles, safety boots, leather gloves, safety helmet
38	Open valves V102 and V103 and close valve V104 **or** open the shut-off device upstream of the TSA	
39	Open ball valves V212 and V222	
40	Vessels are brought to system pressure	
41	Check vessel pressure at NUP 211 and 221 and switch to manual mode when TSA system pressure is reached	
42	Activate flare operation at flare control unit	
43	Close valve NVT 101	
44	Flush X side with landfill gas towards flare by opening valves NVT111 and NVT211 and NVT221 and NVT421	
45	Use suitable measuring equipment to check oxygen content to meet criteria for entering TSA (02 less than 3%)	
46	Flush Y side with landfill gas towards flare by opening valves NVT121 and NVT411 and closing valves NVT111 and NVT421	
47	Use suitable measuring equipment to check oxygen content to meet criteria for entering TSA (02 less than 3%)	
48	Set all NVT valves to normal position as described in "Description of TSA"	
49	Switch off flare demand at flare control unit	
50	Check all top flanges for leaks, place insulation hat, close lids and secure	Personal protective equipment: safety goggles, safety boots, leather gloves, hard hat, fall harness with safety lanyard
51	Start TSA in accordance with "Starting – Operating – Stopping TSA". TSA must be initialised after carbon change and before switchover to automatic mode	
52	Switch TSA to automatic mode	

10. Protective-conductor connection

Unless shorter intervals are specified elsewhere, the protective-conductor connections on the TSA should be inspected at least once every two years by suitably trained and authorised staff to ensure that they are in proper condition.

Measuring points:
According to the diagram, the following cable connections are involved:

+TSA-SSL303	Equipotential bonding, TSA control cabinet
+Z-SSL304/+TSC-SSL304	Equipotential bonding, control module
+X.-SSL305	Equipotential bonding, adsorber modules X (modular only)
+Y.-SSL306	Equipotential bonding, adsorber modules Y (modular only)
+TSA-W.E98.C	Equipotential bonding, TSA control cabinet – control module
+X.-W.E13.C	Equipotential bonding, adsorber modules X – control module (modular only)
+Y-W.E13.C/+TSC-W.E13C	Equipotential bonding, adsorber modules Y – control module (modular only)
+Z-W.M3.C/+TSC-W.M3C	Connecting cable, sensor terminal box – control module frame
+Z-W4.C	Connecting cable, valve terminal box – control module frame (modular only)
+Z-W.M1.C/+TSC-W.M1C	Connecting cable, control module frame – control module support
+Z-W.M2.C/+TSC-W.M2C	Connecting cable, control module frame – control module support
+X./Y.-W.M3.C	Connecting cable, sensor terminal box – adsorber module frame (modular only)
+X./Y.-W.M4.C	Connecting cable, heating element terminal box – adsorber module frame (modular only)
+X./Y.-W.M1.C	Connecting cable, adsorber module frame – adsorber module support (modular only)
+X./Y.-W.M2.C	Connecting cable, adsorber module frame – adsorber module support (modular only)
+X./Y.-W.M101.C/+TSC-W.M101.C	Connecting cable, adsorber module frame – vessel B1 thermal insulation
+X./Y.-W.M102.C/+TSC-W.M102.C	Connecting cable, adsorber module frame – vessel B2 thermal insulation
+X./Y.-W.M103.C/+TSC-W.M103.C	Connecting cable, adsorber module frame – vessel B1
+X./Y.-W.M104.C/+TSC-W.M104.C	Connecting cable, adsorber module frame – vessel B2

Be sure to measure the resistance value of the foundation earthing element and the insulation resistance values between the conductors and earth and between the conductors themselves.
The inspection values should be noted on the test report for electrical installations as required by the authorities (obtainable by the competent trade organisations and/or authorities).

11. Heat-conductor resistance

The resistance values of the heat conductors should be inspected at least every 2 years.

Practical implementation of the inspection:
In addition to the shutdown procedure in accordance with Technical Instruction No. 1100-0106 as described above:
Switch off the power switch in the TSA power cubicle for the heating elements and protect it from unauthorised start-up.

Measuring points:
Use an ohmmeter to measure the resistance values between the following elements in the TSA terminal box:

Vessel B1
+X./Y.-XH/970-N1, 971-N1, 972-N1
+X./Y.-XH/973-N2, 974-N2, 975-N2
+X./Y.-XH/976-N3, 977-N3, 978-N3
+X./Y.-XH/979-N4, 980-N4, 981-N4

Vessel B2 or Y in the case of Compact TSA
+X./Y.-XH/982-N5, 983-N5, 984-N5
+X./Y.-XH/985-N6, 986-N6, 987-N6
+X./Y.-XH/988-N7, 989-N7, 990-N7
+X./Y.-XH/991-N8, 992-N8, 993-N8

Limiting values:
Resistance in 400/230V system:
Minimum value: **20 ohms**
Maximum value: **30 ohms**
If the actual values fall below or exceed the above values, the heat conductors should be replaced.

Resistance in 480/277V system with 3.5kW heating elements:
Minimum value: **15 ohms**
Maximum value: **30 ohms**
If the actual values fall below or exceed the above values, the heat conductors should be replaced.

Resistance in 480/277V system with 2kW heating elements:
Minimum value: **30 ohms**
Maximum value: **50 ohms**
If the actual values fall below or exceed the above values, the heat conductors should be replaced.

Resistance in 600/346V system with 2kW heating elements:
Minimum value: **50 ohms**
Maximum value: **70 ohms**
If the actual values fall below or exceed the above values, the heat conductors should be replaced.

Also be sure to measure the insulation resistance values between the conductors and earth and between the conductors themselves.
The inspection values should be noted on the test report for electrical installations as required by the authorities (obtainable by the competent trade organisations and/or authorities).

12. Option: Electrical equipment for potentially explosive gas atmospheres

Unless shorter intervals have been specified elsewhere, the technical condition of electrical equipment for potentially explosive gas atmospheres should be inspected not less than once every 2 years.

Type of protection “i”:
The components shown in the table and their connections must be subjected to the following visual inspections.

- Documentation for electrical circuits and/or equipment must be consistent with the Zone classification.
- No visible non-conforming modifications.
- Safety barriers are of the certified types, have been installed in accordance with the certificates and safely earthed.
- No visible damage to cables and wiring.
- Sealing of shafts, ducts and pipes is satisfactory.
- Cables and/or wiring which are not in use must be properly terminated.
- Equipment is adequately protected against corrosion, weather, vibration and other potential problems.
- No excessive accumulations of dust or dirt.

Safety barriers	+TSA-Z.
Pressure transducer	NUP211, NUP221, PI301, PI501
Temperature sensor PT100 with head pressure transducer	NUT601, TI311, NUT313, TI321, NUT323, TI322, TI324
Flow meter	FI301, FI501
Limit switches for pneumatic valves	NVT111, NVT211, NVT311, NVT411, NVT121, NVT221, NVT321, NVT421, NVT502, NVT101
Thermocouples and transducers	NUT710, NUT711, NUT715, NUT716, NUT720, NUT721, NUT725, NUT726, NUT712, NUT714, NUT722, NUT724

Type of protection “m”:
The components shown in the table and their connections must be subjected to the following visual inspections.

- Equipment is suitable for the zone.
- Circuit designation is available for equipment.
- Housing and connections are satisfactory.
- No visible non-conforming modifications.
- There is no visible damage to cables and wiring.
- Sealing of shafts, ducts and pipes is satisfactory.
- Equipment is adequately protected against corrosion, weather, vibration and other potential problems.
- No excessive accumulations of dust or dirt.

Relay valves for pneumatic valves	NVT111, NVT211, NVT311, NVT411, NVT121, NVT221, NVT321, NVT421, NVT502, NVT101
Solenoid valves	SOV213, SOV214, SOV223, SOV224

The inspection values should be noted on the test report for electrical installations as required by the authorities (obtainable by the competent trade organisations and/or authorities).

Depending on national regulations, adsorbers may be classed as pressure vessels and must if necessary be inspected as such.