HSE Requirements for steam cleaning and purging

Scope

The following is in scope and out of scope for these requirements.

In scope	Out of scope
Utilizing steam to • eliminate flammable atmospheres from tanks, vessels, and pipelines; • clean equipment prior to repair; or • inert equipment prior to re-commissioning.	Nitrogen purging.

Written plan reviewers and approvers

Each job requires a written plan.

Plan Reviewers	Plan Approvers
Facility Engineer and Company Safety Representative	Equipment owner COPA Tank and Vessel Technical Authority (if applicable), and group executing the work

Components of the written plan

The written plan for the job must include at least the following.

Item	Included
Applicable ASH controls and compliance.	☐
Assigned acceptable LEL for discontinuation of steaming.	☐
Controlling hydrocarbon exposure of personnel to steam plume	☐
Manage vapor from heating NGL within tank, pipeline or vessel.	☐
Ensure connecting lines are rated for intended service.	☐
Mitigate potential for pressure changes, hammering/slugging, freezing, thermal expansion, and damage from heat trace.	☐
Determination of proper vent sizing by Facility Engineer.	☐
Critical parameter table. See section below.	☐
Required equipment list, see section below for possible inclusions.	

Job specific procedures

Job specific procedures must be developed for the following:

- Condensate removal. Including steam inlet size and location, steam vent size and location, demisting provisions, condensation removal process, condensation disposal, and the cooling method.
- Managing escaping or venting steam.
- Contingency planning, including spill response.
- Worker protection if entering vessel/tank.

Equipment list

The following items should be considered for inclusion on the equipment list.

- De-mister on catch tanks.
- Secondary containment for portable tanks.
- Steam hoses rated for appropriate temperature and pressure.
- Hardline and hose connection point.
- Temperature & Pressure Transmitters (consider wireless connected to SETCIM).
- Flow Meter.
- Atmospheric Monitoring Equipment.
- Sampling Connections and Containers.

Critical parameter table

Critical parameters to be monitored

The table of critical parameters below must be monitored during and shortly after steaming. Include in job written plan.

Parameter	Measurement Location(s)	Acceptable Range (Low and High)	Frequency of Measurement or Observation	Device(s) to be Used
Internal Pressure	Include	Include	Include	Include
Internal Temperature	Include	Include	Include	Include
Steam Pressure	Include	Include	Include	Include
Steam Temperature	Include	Include	Include	Include
External Temperature	Include	Include	Include	Include
External Skin Temperature	Include	Include	Include	Include
LEL Content	Include	Include	Include	Include
Oxygen Content	Include	Include	Include	Include
Toxic Gas(es) Content	Include	Include	Include	Include
VOC[1] Content	Include	Include	Include	Include
Heating Rate (Desired)	Include	Include	Include	Not Applicable
Cooling Rate (Desired)	Include	Include	Include	Not Applicable
Pressure Buildup Rate (Maximum Increase)	Include	Include	Include	Not Applicable
Pressure Buildup Rate (Maximum Decrease)	Include	Include	Include	Not Applicable
Duration of Steaming	Include	Include	Include	Not Applicable
Opening Parameters (If Applicable)				
Maximum Temperature Allowed for Opening	Include	Include	Include	Include
Maximum LEL Allowed for Opening	Include	Include	Include	Include
Oxygen Range Allowed For Opening	Include	Include	Include	Include

[1] VOC – Total Volatile Organic Compounds

Engineering guidelines for steaming and cleaning tanks and vessels

Engineering Calculations and Considerations	• **Determine** the total capacity of the tank PSV's including piping and nozzles to be sure the maximum steam flow can be handled without over pressuring the tank. • **Account** for volume of any gases flashed by heat from the steam. (During air freeing, use molecular weight of air rather than steam.) • **Determine** tank heat loss and calculate the minimum amount of steam flow required to maintain the desired temperature. • **Add** allowance for a minimum vent flow to prevent air ingress. This will be the minimum continuous steam flow required. • **Determine** steam heat required to raise the temperature of tank and contents from start point to desired level in a reasonable amount of time. Make sure that the PSV's can handle this flow. • **Determine** vacuum relief requirements so tank will not collapse.
Coating considerations	• **Contact** Tank and Vessel Technical Authority prior to starting any steam work to identify coatings or other temperature sensitive components. • **Aim** steam at the center of the tank/vessel. • **Monitor** steel temperature of the shell at different locations.
Air freeing	• When steam is used for cleaning it may also result in gas freeing. Even if the tank is inerted and purged with nitrogen, steaming after the tank is vented can cause hydrocarbon gas to be liberated from solids and residual contents in the tank. The tank atmosphere can go through an explosive mixture making the environment unsafe. • After air freeing, when the tank is already inert under a steam atmosphere, blanketing gas can be introduced. The positive pressure in the tank is easily maintained because the amount of blanket gas expansion due to heating offsets the change in volume caused by steam condensation. The actual gas volume required will be at least equal to the amount of condensation caused by tank heat loss.
Insulation and steam amount	The amount of steam required will be much larger when the ambient temperature is low for uninsulated tanks.

Efficient methodology

The table below summarizes best practices for efficient steaming.

Tanks	Vessel
Minimally open a small top vent to allow non-condensable and light gases to escape while having a full flow open vent at the tank bottom. This will allow initial venting of the air while keeping further air from entering and lowering the temperature of the tank. Too large an opening on top with a bottom vent fully open will promote an air draft inside the tank (chimney effect) which lowers the temperature of the tank and wastes the steam.	Put a steam hose toward the bottom, a vent on the top open just enough to keep the pressure as low as necessary (often, but not always 0 psig), and a condensate drain on the bottom that is either left opened or opened frequently to drain water until the entire vessel gets up to the temperature where condensation is drastically reduced.
Steam cleaning is more effective if it condenses on the walls of the tank and the temperature is kept at the maximum allowable.	Too large an opening on top with a bottom vent fully open will promote an air draft (chimney effect) inside the vessel.

- It is important to meter steam flow. Do not exceed the maximum flow allowed. Remote monitoring and trending of tank temperatures makes the process a lot more efficient especially if production impact is a big concern.
- Provide a standby boiler to assure that there is a continuous supply of steam or an alternate inert gas supply to maintain positive pressure should the steam supply be interrupted. PSV's should also be able to handle vacuum flow to prevent tank collapse.

Purging to eliminate flammable atmosphere	• When using steam as an inerting agent supply at a rate that will maintain vessel temperature at 180°F or higher. Ensure condensation by cooling does not draw in atmospheric air or collapse the vessel. • Temperature and pressure will vary depending on generator utilized and could range between approximately 300°F - 350°F at 50 - 120 psi. • As steam is introduced into a cool vessel/tank at atmospheric pressure, much of the steam will condense and drop out as liquid water until the vessel temperature reaches approximately 180°F. Consider how much liquid will collect in the bottom of the vessel/tank if it is not drained during the steaming operation. Consider using a pump to drain the liquid. • As steam is introduced it must be vented from the tank/vessel. Facility Engineer will determine size of the required vent(s). • The steam plume exiting a vessel or tank can contain high levels of hydrocarbons. Ensure employees, offices, or air intakes are not in the path of the plume. • As the tank is being steamed, samples can be taken for Lower Explosive Limit, (LEL) and oxygen (O2) content. Samples should be taken at different levels of the tank/vessel. • Once the LEL is less than 50% the vessel may be opened to atmosphere and the steam can be turned off. This will allow air to enter the vessel as the hot steam exits the vent on top. If the vent(s) are not sized properly this could create a potentially catastrophic vacuum situation as the tank/vessel cools. • When opening man-ways the potential exists for employees to be exposed to heat, toxic vapors and water vapor. It is good practice to set up air movers to blow the vapor away.
Steaming to clean equipment prior to repair	After the LEL has been reduced to 50% or lower and the tank/vessel has been opened and inspected, steaming may be resumed for additional cleaning.

Inert equipment prior to re-commissioning	• If steam is used, care must be taken to prevent a vacuum when the cooler product or blanket gas is introduced. • Prior to returning to service the tank must be rendered inert with steam or N2. • If steam is used, the expanding steam will typically push the air out through low points of the tank. Sampling should be conducted for O2 content at these locations. • The expansion ratio from water to steam is approximately 1600 to one. At this rate, and depending on the size and configuration of the tank, it may only take a few hours to push the air out of the tank to a level of less than 5 % Oxygen. Sample at the drain to monitor the oxygen level. • Once the desired oxygen level is reached, the blanket gas can be applied and the steam can be turned off. • It is very important to do this step rapidly once the steam is turned off. The surface area of the tank will start to cool the tank off causing the steam to contract at a ratio of 1600 to one creating a vacuum. • Once the blanket gas has been re-established then product can be put back into the tank safely. • Special consideration should be given to the timing/sequence and exposure while swinging blinds prior to re-commissioning.

Engineering guidelines for steaming pipelines

Guidelines for steaming pipelines

Engineering has provided the following guidelines for steaming pipelines.

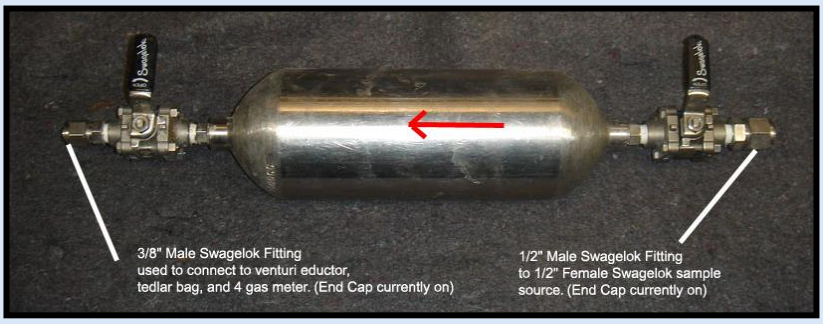
Temperature	**Review** temperature specifications.
Catch tanks	• **Set up** a catch tank for liquids, solids (sand, scale sludge), and high velocity steam. • Catch tank must hold the anticipated amount of waste or be emptied during the cleaning process. • **Position** nozzles on the header so they do not get clogged, and waste does not splash out of the tank. • **Ensure** liquid level in tank does not rise above the inlet header.
Low spots	• **Consider** formation of ice plugs from accumulation of condensed steam low spots. • **Provide** low point drains for overland pipelines during cold ambient temperatures.
Sampling	**Identify** sample points prior to steaming.

CAUTION: Backpressure can allow the temperature to easily exceed 212°F.

Steam sampling procedure

Prepare sample cylinder and sample point (s)

Prepare sample cylinder and sampling point(s)

Step	Action
1.	**Identify** sample points. **WARNING:** A hose may be required from the sample collection point to a safe area. Minimize the distance between the sample point and the sample collection area.
2.	**Set up** sample point with a quarter turn ball valve and a ½" female swagelok connection.
3.	**Equip** each steam sample cylinder with a swagelok fitting. Example below of possible configuration. 

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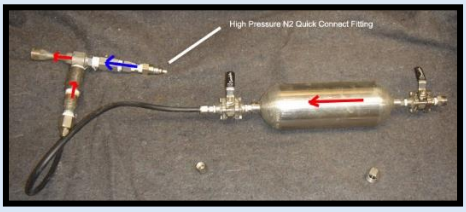
Prepare sample cylinder and sample point (s)

4. **Connect** a sample cylinder to the sample source with Swagelok fitting.

If	Then
steam sample is from a pipeline or smaller vessel	sample can usually be taken directly from the pipeline or vessel using the steam pressure to obtain the sample.
Large tank or vessel	• may require a stainless steel stinger or other device. • may be necessary to pull the sample from various levels in the tank using a venturi-eductor powered by a nitrogen source or other intrinsically safe high vacuum generating device.

5. If using a venturi-eductor, connect the high pressure N2 source hose to the venturi-eductor N2 quick connect fitting (100 ft. length used)



6. Connect a sample cylinder to the sample source using the swagelok fitting.

7. Connect the venturi-eductor or vacuum device to the sample cylinder using the swagelok fitting.

Collect the sample

To collect the sample.

8.	Connecting lines should be made of stainless steel braided flexible hose to prevent melting from high sample temperatures.
9.	Provisions should be made to for spill prevention and to collect condensate from the steam outlet from the eductor or sample lines. Steam samples can contain hydrocarbons and NGL's and should be handled and disposed of properly.
10.	Open cylinder inlet and outlet ball valves.
11.	If a venturi-eductor is used, establish N2 flow to the venturi-eductor.
12.	Open quarter turn valve at the sample point and purge with tank vapors through the sample cylinder
13.	Allow the sample cylinder to reach temperature by flowing steam sample for several minutes. This can be done visually by monitoring the venturi-educted steam. The effluent stream will sputter condensate until the sample cylinder reaches temperature, at which time a steady steam stream will be emitted.
14.	Close sample cylinder valves and capture the sample.
15.	Turn off the vacuum device or the N_2 flow to the venturi-eductor.

Sample is collected and ready to be secured for results.

Secure sample and measure results

To secure the sample and measure results

16.	Secure the sample by placing end caps on each end to guard against inadvertently opening the valve
17.	Handle the hot cylinders with care. Use insulated gloves to avoid contact burns from the hot cylinder(s). (A stand/holder that can be used to transfer the cylinder while hot or simply let it stand until it cools enough to handle safely is advisable).
18.	Place the sample container in a water bath to complete cooling and condense any liquids.
19.	Equalize the pressure in the sample container. 1. Crack one valve and allow the vacuum created in the sample cylinder to draw atmosphere. 2. Close valve after audible hissing stops. (Equalization occurs quickly).
20.	Connect the direct reading gas meter to the sample cylinder using the swagelok adapter.
21.	Submerge the sample cylinder in water up to the upper valve stem. 
22.	Open the bottom valve under water. The water head fills the sample chamber as the vapor is evacuated with the direct reading gas meter pump. This allows the sample to be pulled without a pump failure or change in volume percentage (approximately 2-½ minutes of sample duration required). CAUTION: Use in-line water trap to prevent water from entering the meter.
24.	Compile data results and specific procedures and save copy for future reference.

Steam sampling is now complete.

Steam temperature pressure table

SATURATED STEAM TEMPERATURES

Inches Mercury Vacuum	Absolute Pressure (P.S.I.A.)	Temper-ature Of	Gauge Pressure (P.S.I.G.)	Tempe-rature Of	Gauge Pressure (P.S.I.G.)	Temper-ature Of	Gauge Pressure (P.S.I.G.)	Temper-ature Of	Gauge Pressure (P.S.I.G.)	Temper-ature Of
29.74	0.089	32	0	212	135	358.3	285	417.2	570	483.4
29	0.461	76.5	2	218.5	140	360.8	290	418.7	580	485.2
28	0.942	99.7	4	224.4	145	363.4	295	420.2	590	487
27	1.43	114	6	229.8						
26	1.92	124.6	8	234.6	150	365.9	300	421.7	600	488.8
					155	368.3	310	424.6	650	497.4
25	2.42	133.3	10	239	160	370.6	320	427.4	700	505.4
24	2.91	140.3	15	249.7	165	372.9	330	430.3		
23	3.4	146.3	20	258.8	170	375.2	340	433	750	513.1
22	3.89	151.7							800	520.3
21	4.38	156.5	25	266.8	175	377.4	350	435.6	850	527.3
			30	274	180	379.5	360	438.2	900	533.9
20	4.87	161	35	280.6	185	381.7	370	440.8	950	540.3
19	5.36	165.2	40	286.7	190	383.7	380	443.3		
18	5.85	168.9	45	292.4	195	385.8	390	445.7	1000	546.4
17	6.35	172.5								
16	6.84	175.8	50	297.7	200	387.8	400	448.1		
			55	302.6	205	389.7	410	450.5		
15	7.33	178.9	60	307.3	210	391.7	420	452.8		
14	7.82	181.8	65	311.8	215	393.6	430	455.1		
13	8.31	184.6	70	316	220	395.4	440	457.3		
12	8.8	187.2								
11	9.29	189.7	75	320	225	397.3	450	459.5		
			80	323.9	230	399.1	460	461.7		
10	9.78	192.1	85	327.6	235	400.8	470	463.8		
9	10.27	194.4	90	331.1	240	402.6	480	465.9		
8	10.77	196.7	95	334.6	245	404.3	490	468		
7	11.26	198.8								
6	11.75	200.9	100	337.9	250	406	500	470		
			105	341.1	255	407.7	510	472		
5	12.24	202.9	110	344.1	260	409.3	520	474		
4	12.73	204.8	115	347.1	265	410.9	530	475.9		
3	13.22	206.7	120	350	270	412.5	540	477.8		
2	13.71	208.5								
1	14.2	210.3	125	352.8	275	414.1	550	479.7		
0	14.696	212	130	355.6	280	415.7	560	481.6		