

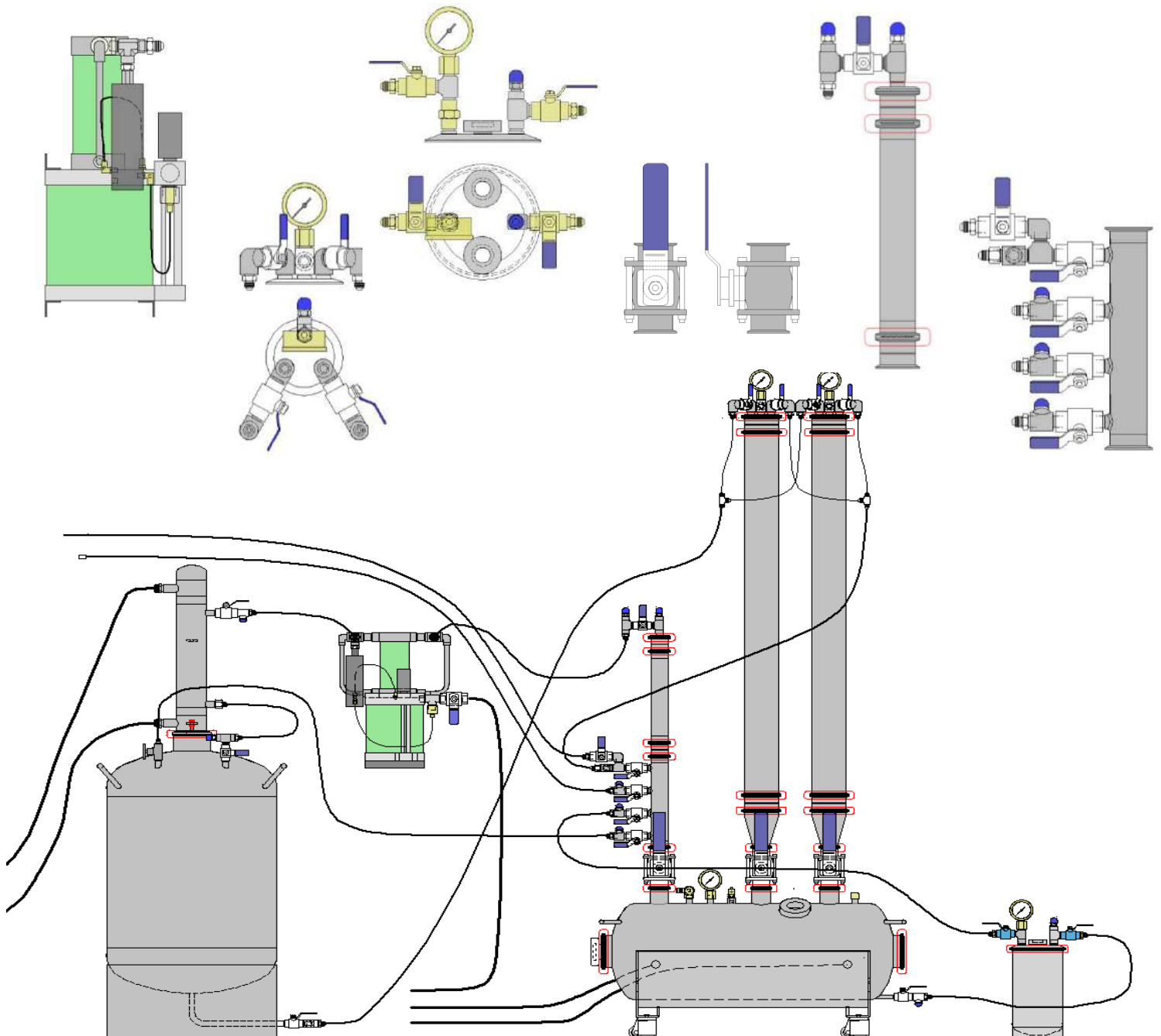
BOTANICAL HERBAL OIL EXTRACTORS

CERTIFIED EXTRACTOR SYSTEMS

ALL MODELS FROM THE CES MATRIX



ASME CERTIFIED – NFPA-58 COMPLIANT
RATED FOR PROPANE & BUTANE / LPG-350





Congratulations for selecting a BHOgart Certified Extractor System. This botanical herbal oil extractor system is designed to effectively extract essential oils and extracts from herbal materials using pressurized light-hydrocarbon solvents. This system is a closed-loop type specifically designed for the use of LPG (propane, butane, or propane-butane mixes) as the extraction solvent. LPG solvent avoids the need to use extreme temperatures or pressures in the extraction process and can be completely removed from the extracted solutes with basic evaporation techniques.

While this manual pertains specifically to BHOgart Certified Extractor Systems (CES), most of the information can be applied to BHOgart non-certified closed-loop systems.

Design

Certified: The system pressure vessels are manufactured and marked ASME certified for MAWP of 250psi @ 100°F, designed for LPG use. The accessories and hoses are rated LPG-350-PSI to meet NFPA-58 regulations for LPG installations. ASME: American Society of Mechanical Engineers; ref. BPVC Section VIII - Rules for Construction of Pressure Vessels Division 1 (BPVC-VIII-1 - 2013). NFPA: National Fire Protection Association; ref. Liquefied Petroleum Gas Code (NFPA-58 - 2017).

Cleanable: The system vessels and accessories are manufactured of food-grade 304/316 stainless steel and are electro-polished for producing pure extracts and ease of cleaning after extraction. Rounded edges, seamless tubing and polished welds help ensure sanitation standards can be met. Many tank models have bottom drains for easier solvent wash-down and sterilization.

Modular: The design of a BHOgart Certified Extractor System allows many variations on the basic extraction process. Available connections, valves and accessories permit a variety of process steps to be used or modified. A wide range of temperatures, pressures and dwell times are possible for different process steps. An enthusiast can certainly develop one's very own special process.

Safety

Flammable: LPG (liquefied petroleum gas: propane, butane, and their mixes) is extremely flammable and can create an explosive atmosphere when mixed with air. LPG becomes explosive at as little as 2% content in air. Keep away from open flames, heat, sparks, and hot surfaces - no smoking.

Leaks: Although BHOgart extractor systems are closed-loop type designs intended to operate without leakage of the LPG, and to recover the solvent after extraction for reuse, some release of LPG must be expected and planned for. The herbal materials may retain some LPG depending on how thoroughly vaporized after extraction, which may be released upon removal from the unit. Some process steps may release a small amount of LPG, as when purging air from a hose. One must plan for the possibility of an operating error or improper seal allowing an outright LPG leak. Equipment must be configured with shutoff valves on every nozzle of every pressure vessel to permit quick isolation of any component.

Heavier-than-air: LPG is heavier-than-air and will sink down to the floor or ground and collect in low areas, corners, basements and crawl-spaces. The basic rule is to never allow an accumulation of LPG at even one-fourth the explosive mix, or less than ½% - that is very little. You cannot smell LPG if not odorized.

Ventilation: The key to safety when extracting using LPG is proper ventilation. Where permitted, operate the extractor system outdoors in an open area away from walls or low spots and away from any sources of ignition. Where necessary to operate indoors, a properly designed hazardous environment facility must be used, with suitable exhaust ventilation for LPG, explosive atmosphere electrical and fire safety equipment, and proper storage of the LPG supply.

PPE (Personal Protective Equipment) is vital for operator safety. Proper gloves and eye or face protection are always necessary. Clothing should cover all flesh and be rated FR for Flame-Resistant (ref NFPA-2113). Besides a flash fire hazard, compressed LPG upon release is very cold and can cause immediate frostbite of any exposed flesh. In addition to an explosion hazard, concentrated LPG can displace air in a confined space and cause asphyxiation without warning. Indoor facilities should and may be required to have LPG gas detector devices to warn of a leak or developing hazard.

Equipment: Electrical equipment within the hazardous area should be rated explosion-proof or intrinsically-safe and be grounded to earth. Exhaust ducting should be rated conductive and be grounded. Exhaust fans should be rated for LPG and be grounded. The recovery pump should be rated suitable for LPG and set-up not to exceed the pressure rating of the recovery tank. The vacuum pump needs to be suitable for LPG and vented outdoors unless only venting air or proceeded by a separator or trap device to remove the LPG before the pump. Firefighting equipment should be ready; at least a portable extinguisher and perhaps a sprinkler or extinguishing system (consult the local fire department).

Safety Valves: Pressure vessels come with pressure relief safety valves, to prevent an excessive gas pressure build-up. They are set to the vessel pressure rating and must not be removed. Accessories, pipes and hoses exposed to liquid LPG must be equipped with a hydrostatic relief valve between any two shutoff valves, to release pressure from liquid expansion due to warming. They are set to 450 psi and must not be removed. A separate new hose or pipe run needs to include a hydrostatic relief valve.

Regulations: The facility must comply with all state and local regulations and codes, which often refer to national standards like NFPA and federal regulations like OSHA (consult the local building and fire departments). For reference, an LPG solvent extraction area within a facility is classified a Class 1, Division 1, Group D explosive atmosphere hazardous area (which may also apply to other areas).

Standards: The design standards for equipment and facilities, and the standard procedures for LPG storage and operating equipment, have been developed to minimize dangers and improve safety. It is critical that these standards and procedures are stringently followed to minimize risks and accidents.

Please give safety it's proper due, so you can enjoy the fruits of your labors. Always, **SAFETY FIRST**.

From MSDS – Material Safety Data Sheet – for LPG

First-aid measures:

After inhalation	Remove victim to uncontaminated area wearing self-contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.
After skin contact	For exposure to liquid, immediately warm frostbite area with warm water not to exceed 105°F (41°C). Water temperature should be tolerable to normal skin. Maintain skin warming for at least 15 minutes or until normal coloring and sensations have returned to the affected area. In case of massive exposure, remove clothing while showering with warm water. Seek medical evaluation and treatment as soon as possible.
After eye contact	Immediately flush eyes thoroughly with water for at least 15 minutes. Hold the eyelids open and away from the eyeballs to ensure that all surfaces are flushed thoroughly. Get immediate medical attention.

Firefighting measures:

Suitable extinguishing media: Carbon dioxide, dry chemical, water spray or fog.

EXTREMELY FLAMMABLE GAS: Forms explosive mixtures with air and oxidizing agents.

EXTREMELY FLAMMABLE GAS: If venting or leaking gas catches fire, do not extinguish flames as flammable vapors may spread from leak, creating an explosive re-ignition hazard. Vapors can be ignited by pilot lights, other flames, smoking, sparks, heaters, electrical equipment, static discharge, or other ignition sources at locations distant from product handling point. Explosive atmospheres may linger. Before entering a confined area, check the atmosphere.

Evacuate all personnel from the danger area. Use self-contained breathing apparatus (SCBA) and protective clothing. Immediately cool containers with water from maximum distance. Stop flow of gas if safe to do so, while continuing cooling water spray. Remove ignition sources if safe to do so. Remove containers from area of fire if safe to do so.

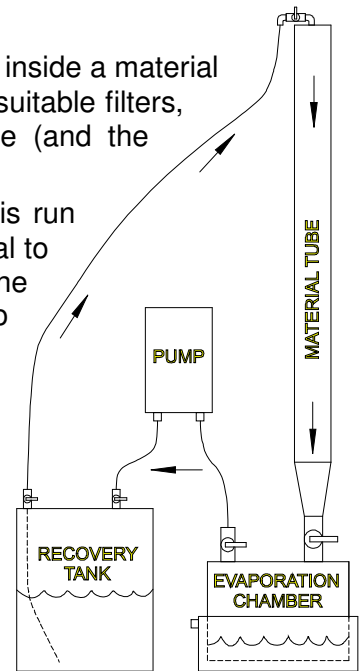
Principle of Operation - Closed-Loop Extraction

Herbal material, after having been dried and trimmed to preference, is packed inside a material tube. The material tube is connected to an evaporation chamber base using suitable filters, valves, clamps or hoses. All air is removed from inside the material tube (and the chamber if not already purged).

Solvent of choice, pressurized to keep it liquid at the desired temperature, is run from a source tank into the top of the material tube, through the herbal material to dissolve the desired extracts. A soaking time can be applied if preferred. The solvent and extract then drains through filters and exit the material tube into the evaporation chamber.

Most of the solvent is then separated from the herbal extract and recovered for reuse, by slightly warming the chamber to evaporate the solvent and pumping the solvent vapor from the top of the chamber. The solvent vapor is condensed back to a liquid into a recovery tank.

Slightly liquefied extract honey that remains in the evaporation chamber can then be transferred into another container for further processing. This transfer may be manual by pouring or scraping, or powered by pumping or gravity, depending on the type of equipment in use.



Additional Accessories

Filter-Dryer: Inline filters, desiccants, and other sieve materials can be added before the pump to clean the solvent of water and other impurities as an integral part of the system, which will help maintain extract quality and extend recovery pump life.

Heat Exchanger: A cold condensing system can be added after the pump to help speed the solvent recovery process by quickly removing the heat added to the solvent for evaporation and added by the pump compression. Eliminate the need to chill the recovery tank to condense the vapor.

Vapor Relief: Filling a recovery tank normally increases the tank pressure being pumped against, but a vapor relief valve can be added connected back to the vapor flow to remove some vapor pressure from the tank.

Material Recovery: Solvent vapor can be recovered out of the top of the material tube to increase total solvent recovery, and to improve safety and meet environmental requirements when handling the spent herbal material.

Continuous Extraction

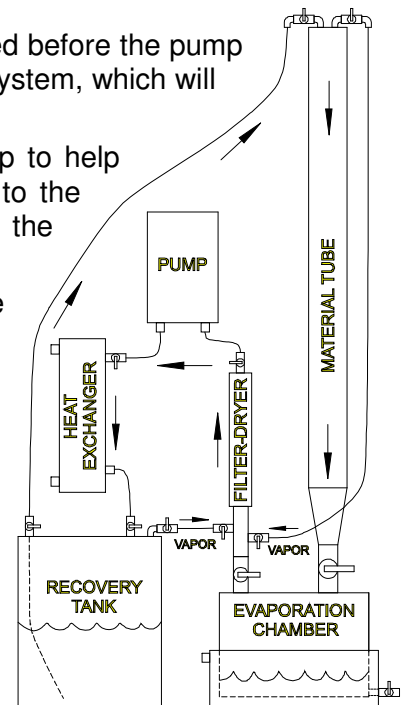
The equipment systems allow replacing a spent material tube with a fresh material tube without stopping the evaporation/recovery process. The system allows isolating the material tube from the system for replacement and then evacuating the air out of the new tube, to allow further extraction while still recovering solvent uninterrupted.

Repeatable control of the process is easier if pure butane or pure propane is used, avoiding LPG mixes that will have changing properties during extended processing due to different evaporation rates.

Many Material Tube Options

Simultaneous connection of multiple material tubes, for quick progression extracting from one material tube to the next for greater production output, is available with some equipment systems. Multiple material tubes may be directly connected to the evaporation chamber or may be rack-mounted with extract hose connections to the evaporation chamber, depending on the model.

Material Tubes, besides being available in various diameters and lengths, are available with cooling ice jackets, cooling/warming water jackets, and vacuum insulating jackets to improve process control. Plus multiple filter plates with various filter media can be used for additional process options.



First Installation

After the extraction facility or area is fully prepared, install the BHOgart Certified Extractor System as follows to confirm all needed components are present and connections are pressure-tight. Reference the system diagrams in the *Appendix*. See the *Maintenance* section for tips on using flare hose fittings and using sanitary tube clamp (TC) connections. Always use HP (high pressure) tube clamps.

Clean

With all new equipment, thoroughly clean all parts to remove manufacturing residues and dust. See the *Cleaning the Equipment* section for tips regarding cleaning.

Evaporation Chamber Assembly

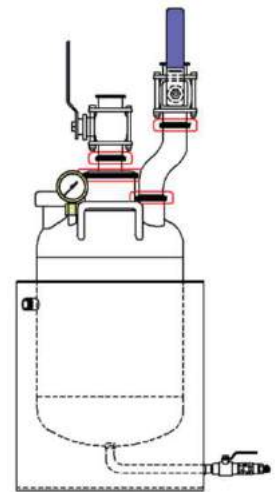
Evaporation chambers are factory fitted with all necessary shutoff valves, safety valves, pressure gauge, sight glasses and access port closures, including the large 2" shutoff valves. Chambers with water jackets need the hose fittings, hoses and valves installed appropriate for the water pumping system. Verify all fittings are tight.

Vertical chambers

Vertical chambers have one 4" TC ferrule drop port that doubles as the access port, and uses a 2"-to-4" concentric expander to mount a 2" TC ball valve.

The bottom-drain vertical chambers have a 2" TC ferrule vapor port, which allows directly chamber-mounting the manifold & filter-dryer assembly onto a 2" TC ball valve using an "S" tube to create clearance from the material tube.

Early model chambers with dip-tube outlets allow a chamber-mounted manifold & filter-dryer assembly by using a 1-1/2" ball valve and 1-1/2"-to-2" TC reducer.

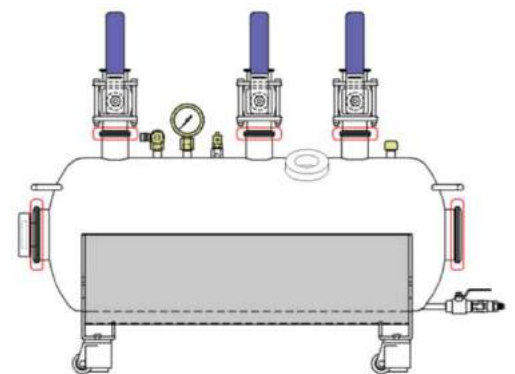


Horizontal chambers

Horizontal chambers offer much more liquid surface area than the same diameter vertical chambers for faster evaporation. They typically have one or more 2" TC ferrule drop ports, and a 2" TC ferrule vapor port, all equipped with 2" TC ball valves, with a bottom-drain, separate access ports on the ends, and a water jacket.

If equipped with other sized drop tubes, use concentric expanders or concentric reducers as necessary to fit the appropriate shutoff valves and material tubes.

Note: A separately-mounted manifold & filter-dryer assembly can be used with any evaporation chamber, via a hose connection to a ball valve at the vapor port.



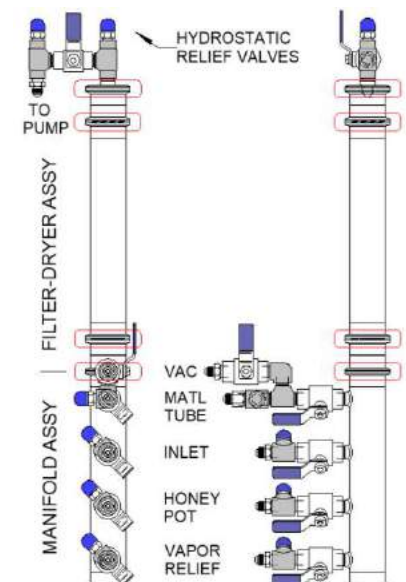
Manifold & Filter-Dryer Assembly

This assumes the manifold tube and the filter-dryer lid are factory fitted with the shutoff and hydrostatic relief valves.

Note: The filter-dryer will be loaded at a later time.

Filter-Dryer Assembly

- 1) Place a 2" screen gasket on the ferrule on one end of a filter plate.
- 2) Place the filter-dryer spool onto that gasket, secure with a 2" clamp.
- 3) Place a 2" screen gasket on the ferrule on the end of the spool.
- 4) Place a second filter plate onto that gasket, secure with a 2" clamp.
- 5) Place a 2" gasket on the ferrule on the end of that filter plate.
- 6) Place the filter-dryer lid onto that gasket, secure with a 2" clamp.



Connect the Manifold & Filter-Dryer to the Evaporation Chamber

- 1) Place a 2" gasket on the ferrule of the chamber vapor port valve.
- 2) Place the manifold assembly on that gasket, rotate the manifold for good valve access and hose routing, secure with a 2" clamp.
- 3) Place a 2" gasket on the ferrule on the top of the manifold assembly.
- 4) Place the filter-dryer assembly on that gasket, rotate the assembly to position the outlet for hose routing, secure with a 2" clamp.

Note: If the manifold & filter-dryer assemblies are mounted separate from the chamber and connected with a hose, the manifold will need a bottom end cap with hose fitting, secured with a 2" clamp, and the chamber will need a ball valve with hose fitting at the vapor port.

Material Tube Assembly

This assumes the material tube lid is factory fitted with shutoff and hydrostatic relief valves. The following is for a 4" diameter material tube, but applies for smaller or larger sizes.

Note: The material tube will be loaded at a later time.

Start with the material tube upside-down...(some tubes have no upside).

- 1) Place a 4" screen gasket on the ferrule at the end of the material tube.
- 2) Place an unloaded 4" filter plate onto that screen gasket, secure with a 4" clamp.
- 3) Place a 4" gasket on the other ferrule of the filter plate.
- 4) Place a 4"-to-2" concentric reducer onto that gasket, secure with a 4" clamp.

Flip the assembly upright...

- 5) Place a 4" gasket on the ferrule at the top of the material tube.
- 6) Place an unloaded 4" filter plate onto that gasket, secure with a 4" clamp.
- 7) Place a 4" gasket on the other ferrule of the second filter plate.
- 8) Place the material tube lid with valves onto that gasket, secure with a 4" clamp.

Repeat for all material tubes to be used.

Note: Rack-mounted material tubes will use a TC head w/ valve fitting instead of the concentric reducer.

Mount the Material Tube Assembly onto the Evaporation Chamber

- 1) Place a 2" gasket on the 2" ferrule of the ball valve of the chamber drop tube.
- 2) Place the material tube concentric reducer on that gasket, secure with a 2" clamp.

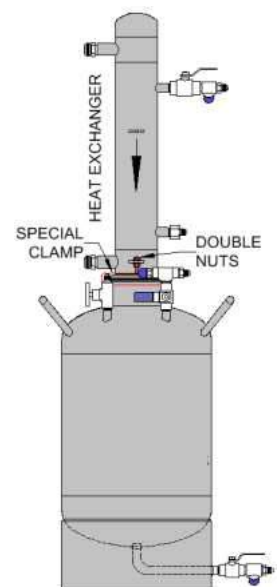
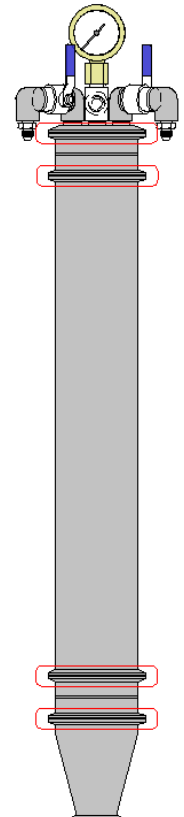
Repeat for systems with multiple material tubes that are directly chamber-mounted.

Note: Rack-mounted material tubes use special adapters on the chamber for connecting the extract hoses from the rack.

Recovery Tank Assembly

Recovery tanks are factory fitted with all necessary shutoff valves, safety valves, pressure gauge, and access port closures and require no further assembly. Verify all fittings are tight.

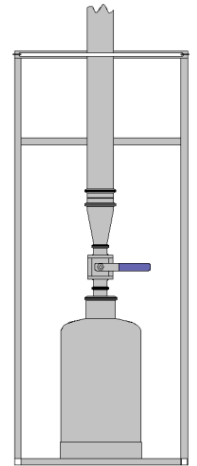
Some recovery tanks can have certain heat exchangers mounted directly on top of the access port cap for convenient, gravity-drainage condensing. If so, a special access port TC clamp with studs is used to hold the heat exchanger in place. Always double-nut the heat exchanger to the clamp, so pressure is not applied toward bending the mounting tabs down or pulling up on the clamp.



Stand Assembly Set-up

Some systems use a stand to prevent the extraction stack assembly or tall recovery tank from falling over, and/or to mount assemblies and accessory devices above the floor. Refer to any instructions provided for the stand or platform in use. Chambers with water jackets typically do not need extra support.

- Place the stand assembly where the system will be operated. Make the stand level and solid to the floor with sufficient headroom for the full height of the equipment.
- For extraction stack support, position the evaporation chamber with material tube assembly in the stand, so the material tube is against the top crossbar of the stand, and then install the rubber strap across the crossbar to hold the tube to the stand.
- Install stand-mounted devices such as manifold & filter-dryer assembly, heat exchanger, recovery pump, or other accessory that will be used and needs support.



Position the System Assemblies and Accessories

Before connecting hoses, all system assemblies and accessories need to be positioned in the operating configuration. Reference the system diagrams in the *Appendix* and any photos and other layout info for the specific system model.

In general, locate tanks for clear access to all valves, with hoses mostly routed to the back side.

A heat exchanger in-line between the recovery pump and recovery tank should be positioned so its outlet is above the recovery tank inlet, to allow gravity-drainage of the heat exchanger. A stand or platform may be needed for this where not mounting the heat exchanger on the top of the recovery tank.

The LPG-rated recovery pump should be positioned with the inlet and outlet as close in height as practical to the filter-dryer outlet and the heat exchanger inlet. A platform, stand or shelf unit may be needed for this. Be sure to follow all manufacturer installation instructions for the pump.

Warnings:

- Any electrical device or pump located near the extraction equipment must be rated explosion-proof or intrinsically-safe for a Class I, Division 1, Group D explosive atmosphere hazardous area.
- Compressed air, vacuum, warm water, and ice water or coolant hoses must all be run in from sources located outside the hazardous area, unless the pumps, heaters and chillers are rated explosion-proof.
- Explosion-proof electrical devices within the hazardous area must be properly wired to the external power sources, typically requiring special conduit and fittings.
- All devices, including tanks, pumps, accessories, stands, ducts and fans, must be cleanly grounded to earth to prevent static charge build-up or discharge.
- A vacuum source or pump needs a vapor trap or separator on the inlet side to prevent solvent from damaging the pump or creating hazardous gas venting at the pump outlet.
- Close attention to preventing any gas leakage and to fresh air ventilation of the extraction area are mandatory for maintaining safe operating conditions.
- Check the local Building and Fire Departments to confirm and comply with all applicable regulations.

Hose Connections

Reference the system diagrams in the *Appendix*.

All hoses must be rated LPG-350-PSI. Always use hoses as short as practical. Route hoses to avoid interference with valve operation, and to avoid damage from sharp bends or being stepped on.

See the *Maintenance* section for tips on using hoses.

Connect the following hoses:

- A) Hose #A from the outlet valve of the recovery tank to the solvent inlet valve of the material tube lid(s).
- B) Hose #B from the vapor port valve of the evaporation chamber to the bottom end cap of the manifold – only used if the manifold & filter-dryer assembly is not directly chamber-mounted.
- C) Hose #C from the outlet valve at the top of the filter-dryer to the inlet of the recovery pump.
- D) Hose #D from the outlet of the recovery pump to the gas inlet valve of the heat exchanger.

- E) Hose #E from the gas outlet of the heat exchanger to the inlet valve of the recovery tank.
- F) Hose #F from the “fifth valve” of the manifold to the external vacuum source.
- G) Hose #G from the “fourth valve” of the manifold to the vapor outlet valve of the material tube lid(s).
- H) Hose #H from the dip-tube or drain tube of the evaporation chamber to the HoneyPot™ inlet valve.
- J) Hose #J from the “second valve” of the manifold to the HoneyPot™ vapor outlet valve.
- K) Hose #K from the “first valve” of the manifold to the #Ki vapor relief (VR²) valve on the recovery tank.
- L) Hose #L from the “third valve” of the manifold is an inlet for solvent filling, bleeding-in air, or other use.
- M) Chamber drop tube valve(s) only receive hoses from separately rack-mounted material tubes. (Special adapters are used for connecting the extract hoses from the rack.)
- N) The chamber direct-inject valve is available for solvent filling, extract-thinning or chamber cleaning.
- P) Connect the pneumatic pump air inlet to the compressed air external source for driving the pumping. Use a short, minimum 1/2" ID hose from a 3/4" ID supply pipe of clean, dry air. A local air regulator (min. 1/2") and pressure gauge may be desired for easy pump output pressure control. This item is not needed for electrically powered recovery pumps.
- Q) Connect the chamber water jacket (if so equipped) by hoses to a warm water source with a pump not exceeding 30 psi. Use a pump rated around 300-GPH (5-GPM). Either jacket hose fitting can be the inlet. The water should typically not exceed 70°F to 80°F to not overheat the extract. Provide for about 20 gallons of water to avoid temperature fluctuation. Heating requirements (watts) will vary with the operating parameters. Note: Electrical devices must be located outside the hazardous area unless rated and installed explosion-proof.
- R) Depending on the heat exchanger (HE) model, cooling may be by water ice slurry or dry ice slurry in the ice pot, or for closed units by hoses connected to a pump and coolant source. This coolant may be ice water or a glycol/water mix. The coolant inlet is at the bottom of the unit to provide the proper counter-flow. Needed flow rate (GPH) varies with the HE model and the operating parameters. It can take from 5-gal to 50-gal of ice water per run: start with at least 60 pounds of ice for an 8-hour day. Alternately, a powered chiller can provide continuous cooling and allows cooling below freezing. Cooling power (watts) vary with the HE model and the operating parameters. Cooling the heat exchanger below 10°F is not recommended. Note: Electrical devices must be located outside the hazardous area unless rated and installed explosion-proof.

Initial Vacuum and Pressure Check Reference the system diagrams in the *Appendix*.

After “First Installation” assembly, the system must be checked for closed-loop pressure tightness. Make sure the system is complete and that all fittings, hoses and TC connections are tightened properly.

Vacuum Check:

- 1) Open all shutoff valves on both ends of hoses #A, B, C, D, E, G, H, J, K and M. Close #F, L and N.
- 2) Turn on the vacuum pump or have the vacuum source available – then open valve #F.
- 3) Watch the evaporation chamber pressure gauge – it should drop to a near total vacuum, reading about 29-InHg. The exact value will vary with the altitude (less at higher altitudes).
- 4) Once the gauge is stable at about 29-InHg, close valve #F. The vacuum pump may be turned off.
- 5) Check all gauges showing vacuum and note needle positions under full vacuum (gauge accuracy).
- 6) Note the time. The vacuum should hold for at least ten minutes. If the vacuum is not held, the vacuum check has failed. The leak must be found and fixed before running the system.

Pressure Check:

- 1) Open all shutoff valves on both ends of hoses #A, B, C, D, E, G, H, J, K and M. Close #F, L and N.
- 2) Connect a compressed air source to hose #L – then open valve #L.
- 3) Watch the evaporation chamber pressure gauge – it should rise as air fills the system.
- 4) When the gauge reads about 120 psi, close valve #L.
- 5) Note the time. The pressure should hold for at least ten minutes. If the pressure is not held, the pressure check has failed. The leak must be found and fixed before running the system.

Loading the Filter-Dryer Assembly

Select the type of filter media and molecular sieve (desiccant) beads or pellets for the type of LPG cleaning needed. Note: Different filters and pellets may be used for initial cleaning of new solvent, versus those used during the normal extraction process.

Typically, 55 micron polyester mesh filter screens are used as filter discs to prevent sieve debris from getting into the pump or extract. Other filters can be used or added for specific cleaning purposes.

Type 3A molecular sieve is a general-purpose drying agent for removing water from hydrocarbons. Type 13X is used for simultaneous H₂O (water) and CO₂ removal, and also for liquid hydrocarbon and natural gas sweetening (H₂S and mercaptan odorant removal). Other types are available and can be used.

Note: Using a longer filter-dryer spool is more effective than using a larger diameter spool for increased solvent cleaning capacity.

See the Maintenance section for more information about desiccant use.

Warning: Ensure there is no pressurized gas in the assembly before starting.

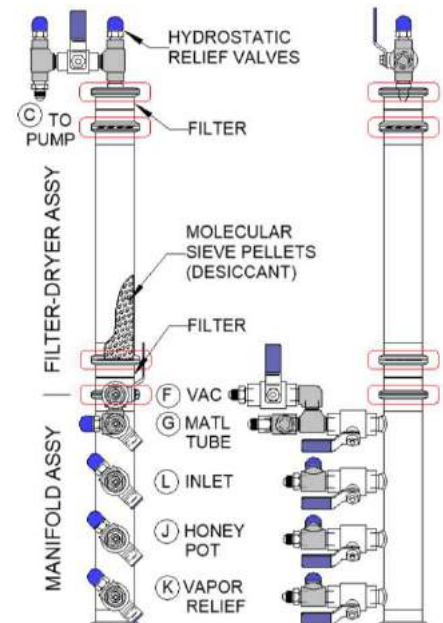
Disassemble the Filter-Dryer Assembly

- 1) Open the top 2" clamp and set aside the lid with valves, leaving the hose attached.
- 2) Open the 2" clamp at the top of the manifold assembly and remove the filter-dryer stack to the filter-dryer reloading station.
- 3) Open the 2" clamp at the top of the filter-dryer spool and, if reloading, remove the desiccant pellets for disposal or regeneration.
- 4) Open the two remaining 2" clamps and, if reloading, properly dispose of the spent filter discs.
- 5) Clean the spool and filter plates as needed.

Load and Reassemble the Filter-Dryer Assembly

- 1) Place a filter disc in a 2" filter plate (secure with a c-ring if needed).
- 2) Place a 2" screen gasket on the ferrule on that end of the filter plate.
- 3) Place the filter-dryer spool onto that gasket, secure with a 2" clamp.
- 4) From the other spool end, load the desiccant pellets to fill the spool.
- 5) Place a 2" screen gasket on the ferrule on that end of the spool.
- 6) Place a 2" filter plate onto that gasket, secure with a 2" clamp.
- 7) Place a filter disc in that filter plate (secure with a c-ring if needed).
Return from the reloading station to the system location...
- 8) Place a 2" gasket on the ferrule at the top of the manifold assembly.
- 9) Place the filter-dryer stack onto that gasket, secure with a 2" clamp.
- 8) Place a 2" gasket on the ferrule at the top of the filter-dryer stack.
- 9) Place the filter-dryer lid onto that gasket, secure with a 2" clamp.

Note: Multiple filter-dryer stacks can be preloaded for quick exchanges.



Loading New Solvent

Reference the system diagrams in the *Appendix*.

Use proper eye, hand and clothing PPE to protect from frostbite and fire. Ensure proper ventilation is operating effectively and warning sensors are working.

If purified LPG solvent is supplied, recovery tanks can be filled directly through the valve #E tank inlet, but distilling to purify even high-grade solvent is recommended. Take care to prevent tank overfilling. Never load liquid solvent in excess of 80% of the recovery tank volume, as space for thermal expansion must be maintained to prevent the safety valve from blowing-open and releasing LPG into the area. Follow all standard LPG tank-to-tank fill procedures.

New LPG solvent should be purified by distillation using the system's filter-dryer system. The new solvent is loaded into the evaporation chamber, as follows:

- 1) After the system has passed initial vacuum and pressure checks and the filter-dryer assembly is loaded for solvent cleaning, again pull a vacuum on the system and verify closed-loop tightness. It is **CRITICAL THAT ALL AIR IS PURGED FROM THE SYSTEM BEFORE LOADING ANY LPG.**
- 2) Close all valves to isolate the various assemblies while maintaining this complete vacuum.
- 3) Attach the solvent-filling hose from a solvent supply tank dip tube outlet to valve #N direct-inject. Leave valve #N closed for now.
- 4) Open the dip tube valve on the solvent supply tank to pressurize the hose.
- 5) “Burp-Purge” the hose to remove any air: Use a wrench to protect hands, slowly unscrew the hose fitting at valve #N until a little solvent just barely starts to squirt out – purging the air out of the hose – and quickly screw back the fitting and tool-tighten. Minimize the release of LPG into the air.
- 6) To track solvent use by weight, a scale is needed under the solvent supply tank. Before transferring the solvent, record the starting weight (or “zero” the tare) on the scale. Note: Make sure the scale is safe for use in an explosive atmosphere.
- 7) Leaving all other valves closed, open valve #N – solvent will shoot into the evaporation chamber.
- 8) The gauge on the chamber will show rising pressure. The pressures in the two tanks may equalize, in which case the flow will slow then stop. If the pressure equalizes, warming the source tank with warm water will raise the vapor pressure and transfer more solvent.
- 9) As solvent flows into the evaporation chamber, watch the scale to prevent overfilling. Never load liquid solvent in excess of 80% of the recovery tank volume. Depending on the size of the evaporation chamber, it may take multiple cleaning loads to fill a large recovery tank.
- 10) Close valve #N on the evaporation chamber and close the valve on the solvent supply tank. The supply tank should then be removed from the area. A small amount of LPG will be lost to the air when the hose is disconnected (the shorter the hose the better); proper ventilation is mandatory.

Purifying New Solvent

Reference the system diagrams in the *Appendix*.

The new solvent will be distilled by vaporization in the evaporation chamber, pumped through the filter-dryer for cleaning, and condensed into the recovery tank, which is under vacuum or partly filled.

- 1) After *Loading New Solvent*, all valves of the system are closed. Open all valves #B, #C, #D and #E and turn ON the recovery pump – solvent vapor will begin flowing from the chamber, through the manifold, filter-dryer, recovery pump and heat exchanger, into the recovery tank.
- 2) Run the evaporation chamber warming system at about 60°F to vaporize the solvent without boiling contaminants. Warming the chamber is vital to provide the energy to evaporate the liquid LPG.
- 3) The heat exchanger condenser needs to operate with ice water or coolant below 40°F to remove that added heat energy and help condense the LPG back into liquid.
- 4) The recovery tank now contains both vapor and liquid LPG. While the recovery pump is running, remove vapor to reduce recovery tank backpressure by opening valve #K, the “first valve” on the manifold, and open one-fourth-turn (1/4th) the #Ki vapor relief (VR²) needle valve on the recovery tank. As the pump runs and solvent is transferred, the pressure in the evaporation chamber will slowly go down. To get below about 10 psi, close the #K and #Ki valves to stop the vapor recycling.
- 5) Before all solvent is vaporized and some liquid remains in the evaporation chamber, close valve #B so chamber pressure can rise, then drain the last of the solvent into an empty HoneyPot™ to flush the contaminants out of the evaporation chamber. Separately vent and clean the HoneyPot™.
- 6) After draining, open valve #B and complete all evaporation from the chamber down to a vacuum.
- 7) Close valves #B, C, D, and E, and then turn OFF the recovery pump. The new solvent is now purified and in the recovery tank. Turn OFF any heating and cooling devices in use.
- 8) Inspect the evaporation chamber, which should be clean and ready for use, but if contamination is visible the chamber will need cleaning. Solvent can be added through valve #N for additional flushing, or the evaporation chamber can be opened for manual cleaning.

- 9) To open the evaporation chamber, properly vent the chamber as some LPG vapor will remain. Open an access port of the evaporation chamber. With vertical chambers, lift off the material tube assembly, valve and adapter. Remove the gasket for possible reuse.
- 10) Clean the inside bottom of the chamber as necessary to remove any residue. Use isopropyl alcohol or acetone and towels to wipe the bottom clean. A solvent-safe hand spray bottle with 75% IPA and 25% acetone is helpful. Avoid sloshing cleaning solvent as it may dirty more of the inside surface. Use appropriate gloves, eye protection, respirator and ventilation for the cleaning solvent in use.
- 11) Reinstall the access port cap or adapter and valve.

Note: Due to contaminants in the new solvent, it may be preferable to reload the filter-dryer now.

Loading the Material Tube

Reference the system diagrams in the *Appendix*.

The material tube assembly will be loaded with the herbal material and the filtering media.

Note: Systems with multiple material tubes simultaneously connected may be extracting from one material tube while another tube is being reloaded. See the separate section below for details.

Disassemble, empty and clean the Material Tube Assembly

Warning: Before starting, ensure no pressurized gas is in the material tube assembly to be loaded.

Verify that all shutoff valves at the top and bottom of the material tube are closed.

- 1) Open the top TC clamp and set aside the material tube lid with valves and hoses attached.
- 2) Open the bottom TC clamp at the top of the concentric reducer, remove the material tube stack and transfer to the Material Tube Reloading Station. Retain gaskets for possible reuse.

With rack-mounted material tubes, the TC heads w/ valve used instead of concentric reducers may stay with the system or by disconnecting extract hoses go with the rack to the reloading station.

Note: A Material Tube Reloading Station needs ample ventilation to vent the LPG retained in the spent plant material. Thorough vapor recovery from the material tubes can greatly reduce this factor.

- 3) Open the TC clamps at the top and bottom of the material tube spool, remove both filter plates, remove the spent herbal material from the tube spool for proper disposal, and dispose of any spent filter media from both filter plates. Retain gaskets for possible reuse.
- 4) Clean the material tube spool and filter plates as needed.

Load and Reassemble the Material Tube Assembly

- 1) Take a micron filter screen and insert it into a filter plate together with the c-ring, so the screen is flat and covers all sides of the c-ring, making sure the screen fits evenly. Stack as many filter screens and c-rings as desired and hold with the c-ring-clip.
- 2) Place a TC screen gasket on the ferrule on that end of the filter plate.
- 3) Place the material tube spool onto that screen gasket and secure to the filter plate with a TC clamp.
- 4) Pack the herbal plant material that has been dried and trimmed as preferred into the tube evenly and tightly working completely to the top, avoiding air gaps or dense spots.

Note: The means of drying and degree of dryness of the herbal material will vary depending on individual preferences. Avoid damp material that will introduce excessive water. Specific recommendations for trimming or grinding the material, the size of pieces and degree of packing are outside the scope of these instructions. Avoid machine grinding powder that may prevent solvent flow.

- 5) Load the top filter plate with a filter screen like in step 1.
- 6) Place a TC screen gasket on the ferrule at the top of the loaded material tube spool.
- 7) Place the top filter plate onto that gasket and secure with a TC clamp.

Return the loaded material tube from the reloading station to the system location...

- 8) Place a TC gasket on the open concentric reducer on the chamber and carefully lift the loaded material tube stack and place onto that gasket, secure with a TC clamp. With rack-mounted material tubes, reinstall the TC heads w/ valve or connect the extract hoses.
- 9) Reinstall the material tube lid using a TC gasket, secure with a TC clamp.

10) Verify that all the clamped connections just reassembled are properly seated and secure.

Note: Multiple material tube assemblies can be preloaded for quick exchanges later.

Purging Air from the Material Tube Reference the system diagrams in the *Appendix*.

Note: Systems with multiple material tubes simultaneously connected may be extracting from one material tube while another tube is being reloaded. See the separate section below for details.

This assumes a freshly loaded material tube is installed. All air must be purged from the system:

- 1) Open valve #Gi material tube vapor outlet, with all other valves closed (#G remains closed).
- 2) Turn on the vacuum pump or with the vacuum source available: open valve #F to apply vacuum to just the material tube.
- 3) Watch the material tube pressure gauge – it should drop to a near total vacuum, reading about 29-InHg. The exact value will vary with the altitude (less at higher altitudes).
- 4) If hose #A has air in it, open valve #Ai material tube inlet (#A remains closed).
- 5) If the evaporation chamber is not isolated under vacuum (and not being kept sealed with extract during a material tube reload) open valves #B and #G to apply vacuum to the evaporation chamber.
- 6) The recovery pump and heat exchanger assemblies should still be isolated under vacuum; if not, also open valves #C and D, with #G open (#E remains closed).
- 7) The HoneyPot™ assembly should still be isolated under vacuum; if not, also open valves #J, Ji and Hi, with #G open (#H remains closed), or use the separate vacuum port if the HoneyPot™ has one.
- 8) Once the gauge is stable at about 29-InHg, close valve #F. The vacuum pump may be turned off.
- 9) Note the time. The vacuum should hold for at least ten minutes. If the vacuum is not held, the vacuum check has failed; find and correct the leak before running the system any further.
- 10) Close all valves; the system is loaded and under vacuum.

Extracting from the Material Reference the system diagrams in the *Appendix*.

Note: Systems with multiple material tubes simultaneously connected may be extracting from one material tube while another tube is being reloaded. See the separate section below for details.

Note: The extractor system runs by differential pressure between the recovery tank and the material tube/evaporation chamber. There needs to be a starting pressure of at least 20 psi in the recovery tank (check the gauge) for the system to run properly. Pure propane achieves this pressure at about 0°F, but pure butane needs to be almost 80°F to provide this vapor pressure (LPG mixtures are between these temps). The vacuum in the material tube will pull some cold low-pressure solvent from a tank, but usually not enough. It may be possible to use the recovery pump to pressurize the recovery tank for system operation with cold solvent.

This assumes a freshly loaded material tube is installed, solvent is ready in the recovery tank, all air has been purged from the system, and all valves are closed; use proper PPE as previously discussed:

- 1) Open valve #Ai material tube inlet. Then open valve #A recovery tank outlet. Solvent will shoot up hose #A into the material tube (the hose may wiggle with the liquid flow). Solvent expansion into the vacuum will cause immediate chilling at the top of the material tube as the tube fills with solvent.
- 2) When the material soaking dwell time has elapsed, or immediately if not soaking, open big valve #M on the evaporation chamber under the material tube. Extract solvent will flow through the herbal material and filter media into the evaporation chamber.
- 3) Close both valves on hose #A before the evaporation chamber can be overfilled, or when the pressure on the evaporation chamber gauge equals the pressure on the recovery tank gauge as the extraction flow has stopped.
- 4) In time, it may be preferable to close big valve #M to stop draining the last of the solvent extract that may contain mostly undesirable solutes. Viewing the flow through a sight glass may help with this.

Note: Not running the recovery pump during extraction lessens freezing due to LPG expansion and reduces vaporization in the material tube. Wait until solvent is about one inch deep in the evaporation chamber before starting the recovery pump.

Multiple Material Tube Use

Systems with multiple material tubes simultaneously connected are intended for sequential extraction. Extraction from one material tube needs to be completed before starting extraction from the next material tube. However, vapor recovery from an extracted material tube can continue while the next material tube undergoes solvent extraction.

Evaporation chambers with multiple drop tubes for multiple material tubes are intended to minimize system downtime loading tubes by allowing extraction from one material tube while reloading another.

Rack-mounted material tubes take this approach further, allowing setting-up a system for continuous extraction without single material tube exchanges. Whole racks of material tubes can be exchanged.

Whether chamber-mounted or rack-mounted, close attention must be directed to proper valve use to operate multiple material tubes safely and effectively. Control between material tubes is primarily by the valves at the material tube lids (#Ai and #Gi), as valves #A and #G will mostly remain open. Rack-mounted setups also require attention to the extract hoses and valves at the bottom of the tubes.

Attention is also needed to ensure the evaporation chamber is not overfilled during continuous extraction. The rates of extraction and solvent recovery will vary widely with the solvent mix, temperatures and pressures in use, equipment types and sizes comprising the system, recovery pump and heat exchanger effectiveness, and numerous operating techniques.

Recovering the Solvent

Reference the system diagrams in the *Appendix*.

Solvent will be separated from the extract in the evaporation chamber and returned to the recovery tank.

Note: It may be desirable to start the solvent recovery process before the extraction is finished.

Any evaporation chamber warming system should be operating to help evaporate the solvent. This heating should be set for 70°F to 80°F (21°C to 27°C).

The heat exchanger should be pre-chilled by coolant, ice water or ice slurry, depending on the set-up, at 40°F or less. Follow the instructions for the model heat exchanger and coolant system in use.

This assumes extract solvent is in the evaporation chamber, the filter-dryer is ready to process solvent, and the whole system remains gas-tight:

- 1) Open all valves #B, C and D to the manifold, pump and heat exchanger.
- 2) Turn ON the recovery pump and open valve #E recovery tank inlet. Solvent will evaporate in the chamber leaving the extract behind, be purified through the filter-dryer, condensed in the heat exchanger, and stored back in the recovery tank.
- 3) Watch the pressure gauges: the higher the pressure in the evaporation chamber the more efficient the recovery pump will run.
- 4) The recovery tank contains both vapor and liquid LPG. The pressure in the recovery tank should be 20 psi to 50 psi depending on the solvent mix (lower with butane, higher with propane). While the recovery pump is running, the tank pressure rises, which can slow recovery. Remove some of the tank vapor pressure by opening valve #K, the “first valve” on the manifold, and open one-fourth-turn (1/4th) the #Ki vapor relief (VR²) needle valve on the recovery tank. Adjust the #Ki valve to control the recovery tank pressure. The more the #Ki valve is open the lower the recovery tank pressure, but if too low then excessive vapor is recirculating, which will slow the pumping and recovery will actually take longer.
- 5) Close big valve #M to stop draining the last of the solvent extract that may contain mostly undesirable solutes. Viewing the material tube flow through a sight glass may help with this.
- 6) Open both valves on hose #G to recover solvent remaining in the material tube. If so equipped, warming the material tube will help vaporize the solvent remaining in the herbal material.
- 7) When the evaporation chamber pressure drops to about 10 psi, or the extract is as thick as desired, close valves #B and #M to stop further evaporation. Material tube vapor recovery may continue; if the material tube recovery finishes first, close both valves on hose #G and the material tube can be exchanged or reloaded while solvent recovery continues.

Transferring the Extract

Reference the system diagrams in the *Appendix*.

Extract will be transferred from the evaporation chamber to the HoneyPot™ for further processing and to free the extractor for additional material extraction.

The recovery pump is still running, valves #B and #M are closed, both valves on hose #G may be open, valves #K and Ki are open, and the HoneyPot™ including hoses #H and #J are under vacuum:

- 1) Open both valves on hose #H evaporation chamber drain; the extract solution will transfer into the HoneyPot™. Be careful not to overfill the HoneyPot™. Multiple HoneyPots™ may be needed to hold a full extraction run, especially if multiple material tubes are extracted.
- 2) Open both valves on hose #J, if necessary to suck extract solution from the chamber.
- 3) Close valve #H evaporation chamber drain to stop HoneyPot™ filling.
- 4) Continue to remove solvent vapor from the HoneyPot™ through the #J hose to achieve the desired thickness of the extract, depending on one's preference for further extract processing.
- 5) Close all valves on hoses #H and #J to complete the transfer.

Note: The HoneyPot™ can be exchanged for an empty unit and the transfer process repeated. Be sure to remove air from hoses #H and #J as well as the HoneyPot™ – use a “T-Valve” hose tap fitting on the #J hose if the HoneyPot™ lid is not equipped with a vacuum port.

Note: Recommendations for further processing the extract are outside the scope of these instructions.

System Shutdown

Reference the system diagrams in the *Appendix*.

Warning: Always be certain all pressure is relieved from a vessel or accessory before opening any clamp, closure or hose. Pressurized closures can explode open, causing damage or injury, and sudden decompression of LPG can cause frostbite to any exposed eyes or flesh. Check all pressure gauges.

The recovery pump is still running and valves #B and M are closed:

- 1) Complete all solvent recovery from the evaporation chamber and material tubes: open valves #B, G and Gi as necessary and wait for the chamber pressure to be a vacuum (0 to 22-InHg).
- 2) Close valves #C, D, E, G, Gi, K and Ki, and then turn OFF the recovery pump. The solvent is now purified and in the recovery tank and the extract has been transferred to one or more HoneyPots™.
- 3) Turn OFF any heat exchanger pump and evaporation chamber heating system in use.
- 4) Open briefly then close the valves on hose #E to drain any liquid LPG condensed in the heat exchanger into the recovery tank.
- 5) Ensure all valves are closed.
- 6) To keep the evaporation chamber and filter-dryer sealed while reloading a material tube, keep valves #B and M closed until starting the next “*Extracting from the Material*” step. Continue at the “*Loading the Material Tube*” section.
- 7) Only if opening the system to air: The evaporation chamber and material tube(s) should be under a slight vacuum, release this vacuum by opening valve #L manifold inlet to allow air in while opening valves #B, G and Gi. If slightly pressurized, use the vacuum system through valve #F to safely remove the remaining vapor, then open to air. This may allow a small release of LPG vapor.
- 8) If not keeping the chamber sealed, an evaporation chamber access port may be opened to manually collect any remaining extract residue or to clean the inside of the chamber. This may be unnecessary if immediately running another extraction batch or using solvent cleaning techniques.
- 9) Contingent on how many contaminants were in the solvent vapor, primarily water from the herbal material, it may be necessary to replace the filter disc and desiccant pellets in the filter-dryer. Desiccant replacement after every full run is recommended as inexpensive quality insurance. The filter-dryer can be isolated from the evaporation chamber by keeping valve #B closed, and evacuated of air by the vacuum through valve #F.

Emergency Shutdown

In an emergency situation, immediately evacuate the area and call 911 for help.

For quick system shutdown, close all valves on the pressure vessels and turn off all pumps, heaters and accessories. The equipment is designed to safely contain the solvent that is in any of the vessels.

The system can then be drained of all solvent by venting to the outdoor atmosphere. Ensure the venting is into an open outdoor area where the LPG will safely dissipate. LPG is extremely flammable, heavier than air, and odorless, so it must not be allowed to collect in an enclosed or low space. A long hose may be needed if the equipment cannot easily be moved outside. Depending on the equipment configuration, various valves will need to be opened to vent all the vessels and hoses. Some residual solvent will remain in the vessels and in any wetted plant material, varying with temperatures and shapes. Careful handling and disposal of all materials is warranted.

Cleaning the Equipment

The equipment should be kept clean and dry to maintain sanitary conditions and avoid corrosion. It is much easier to clean just after use before surfaces dry. Dried residue can be difficult to remove. Clean metals first with a spray of vinegar diluted with water and a soft cloth. Stubborn residue may need isopropyl alcohol or acetone for removal. A solvent-safe hand spray bottle with 75% IPA and 25% acetone is helpful. Use appropriate PPE and adequate ventilation for the cleaning chemicals used.

Cleaning the evaporation chamber between each run is not required unless the herbal material is changed and mixing residue between runs must be avoided. Cleaning the chamber with alcohol allows collecting that fluid to be processed later to remove the alcohol and recover additional usable extract. Wipe with particle free cleaning cloths, not cotton or paper towels.

Hoses and gaskets are made of various elastomers and can generally be wiped clean. Avoid solvents. The black LPG350 hose has a Neoprene outer cover and Nitrile inner hose. The gaskets are Buna-N (Nitrile), Viton (FKM), or Teflon (PTFE). For gaskets, use food grade oil such as olive oil and a particle free cloth. For hoses, water with a mild dishwashing soap is good for the exterior. The inside of hoses can be cleaned if necessary by flushing with ethyl or methyl alcohol and air drying.

Dried residue can make ball valves inoperable and constrict orifices, so any tubes, valves or hoses exposed directly to the herbal material or its extract need particular attention when cleaning.

Maintenance

BHOgart equipment operators should read and follow all operating and maintenance procedures recommended by our manufacturers for their pumps, ovens and accessories. These are contained in user manuals provided by the manufacturers. If you do not understand anything in them or in this document, please call us for clarification.

TC Clamped Connections

All TC clamped connections must be straight and evenly compressed before use. Clamps and bolts need visual inspection before and after each use, looking for any deformation. If any clamp is deformed at all, fits differently, or touches on both ends when tightened, it needs immediate replacement. All bolts and nuts on the clamps should be tightened to 20 ft-lb torque, preferably using a torque wrench. Replace any bolts or nuts showing any sign of thread galling. Brass nuts are intended to be replaced after each use. Gaskets should be inspected every time exposed and replaced if deformed or damaged.

Pipe Thread Connections

Fittings and valves with pipe thread connections are sealed for LPG use. If installing a pipe thread fitting, wrap the male pipe threads with four (4) wraps of fresh, yellow (for gas) PTFE (Teflon) tape before installing the fitting. Pipe threads should be tightened hand-tight and then wrench-tightened 2 to 3 full-turns. Do not back-off any tightened pipe fitting. Pipe threads are not designed for repeated installation, so minimize removal of threaded fittings and be careful not to over-tighten.

Hoses

All hoses need inspection for cracks in the rubber portion and wear in the metal portions before every use. Any visible signs of wear should immediately disqualify the hose from further use. The flare fittings should be tightened to 6-9 ft-lb torque. Do not use Teflon tape with flare fittings. Avoid disconnecting hoses as much as possible to reduce wear on the fittings. If disconnected, the fittings should be inspected and hose replaced if any metal shavings or cross-threading is present.

Note that all hoses where both ends can be closed-off with valves must have a hydrostatic relief valve for LPG (400-500 psi) installed on the hose side of the valve at one end, to prevent bursting if closed when liquid-filled and the temperature warms (NFPA-58). Thermal expansion of the liquid can quickly create 1000's of PSI and burst pipes and hoses.

Filter-Dryer (desiccant tube)

The Filter-Dryer should have a filter disc inserted in each filter plate to prevent desiccant debris falling into the evaporation chamber or passing into the recovery pump. The desiccant pellets should completely fill the filter-dryer spool. Using a longer filter-dryer spool is more effective than using a larger diameter spool for increased solvent cleaning capacity

Select the type of filter media and molecular sieve (desiccant) beads or pellets for the type of LPG cleaning to be completed. Different filters and pellets may be used for initial cleaning of new solvent, versus normal extraction processing. Contact BHOGart for information about LPG purification.

Typically, 55 micron polyester mesh filter screens are used as filter discs to prevent sieve debris from getting into the extract or pump. Other filters can be used or added for specific cleaning purposes.

Type 3A molecular sieve is a general-purpose drying agent for removing water from hydrocarbons. Type 13X is used for simultaneous H₂O (water) and CO₂ removal, and also for liquid hydrocarbon and natural gas sweetening (H₂S and mercaptan odorant removal). Other types are available and can be used.

The desiccant pellets will hold water up to 20% their weight; however, it is not easy to weigh them during use. The amount of water entering the system will vary with how wet or dry the herbal material processed. Some users rarely need to change the desiccant, but with wetter materials the desiccant will need changing more often. Since the pellets are relatively inexpensive, it is recommended that they are replaced every full extraction run. While it is possible to dry the pellets for reuse (on a cookie sheet at 500°F for 8 hours), it is essentially not worth the effort.

Cleaning a Contaminated Tank

To clean a potentially contaminated recovery tank, while preserving the solvent supply, dump the LPG into an evacuated evaporation chamber. A material tube can be filled with desiccant pellets and filter screens and used to purify the solvent while being transferred to the chamber. The emptied recovery tank must be warm (minimum 80°F) with open valves to ensure there is no LPG remaining inside. Then the recovery tank access port can be opened and a light shined inside for inspection. If needed, clean the tank with isopropyl alcohol or acetone, followed by dry compressed air if required. Wipe with a particle free cleaning cloth if necessary. The tank must be completely dry of cleaning fluids before being closed. Then recover the LPG from the chamber into the recovery tank (see *Purifying New Solvent*).

Storing the Equipment

The BHOGart tanks and vessels are not designed for long-term gas storage. When not in use but still holding gas, they should be stored with all valves in a locked, closed position, and with caps on the hose fittings. They should be stored in a locked, shaded, screened, outdoor storage area similar to those you see at Lowes or Home Depot.

Transporting the Equipment

If you wish to travel with your BHOGart equipment, you must empty and clean the tanks, as they are not Department of Transportation (DOT) certified. You can transfer the LPG to a DOT certified tank or recover directly into one. Note: Always purify the solvent when reloading the BHOGart from a DOT container to prevent introducing rust or other contaminants often found in transport vessels.

Appendix

Propane & Butane Data

Properties of		Natural Gas	Propane	Butane
Chemical formula		CH ₄	C ₃ H ₈	C ₄ H ₁₀
Boiling point of liquid at atmospheric pressure	°F	-258.7	-44	32
Specific Gravity of vapor (Air = 1)		0.6	1.53	2.00
Specific Gravity of liquid (Water = 1)		0.6	0.51	0.58
Calorific value @ 60 °F	BTU/cuft	1012	2516	3280
	BTU/gal		91,690	102,032
	BTU/lb		21,591	21,221
Latent heat of vaporization	BTU/gal	712	785.0	808.0
Liquid weight	lbs/gal	2.5	4.24	4.81
Vapor volume from 1 gallon of liquid at 60 °F	cuft		36.39	31.26
Vapor volume from 1 lb. of liquid at 60 °F	cuft		8.547	6.506
Combustible limits	% of gas in air	5 - 15	2.4 - 9.6	1.9 - 8.6
Amount of air required to burn 1 cuft. of gas	cuft	9.53	23.86	31.02
Ignition temperature in air	°F	1200	920 - 1020	900 - 1000
Maximum flame temperature in air	°F	3568	3595	3615
Octane Number		100	Over 100	92

All data is approximate. For actual properties of any particular batch, contact your fuel supplier.

Temperature Conversion Table	
°F	°C
-50	-45.6
-40	-40.0
-30	-34.1
-20	-28.9
-10	-23.3
0	-17.8
+10	-12.2
20	-6.7
30	-1.1
32	0
40	+4.4
50	10.0
60	15.6
70	21.1
80	26.7
90	32.2
100	37.8
110	43.3
120	48.9
130	54.4
140	60.0
150	65.6
160	71.1
170	76.7
180	82.2
190	87.8
200	93.3
212	100

Formula:
 Degrees C = (°F - 32) x 5/9
 Degrees F = 9/5 x °C + 32

Approximate Vapor Pressure in psig											
Temperature		Propane → To → Butane									
° F	° C	100%	95/5'	80/20	70/30	60/40	50/50	40/60	30/70	20/80	100%
-40	-40	1.5	1.4	1.2	1.1	0.9	0.8	0.6	0.5	0.3	
-30	-34.4	5.6	5.3	4.5	3.9	3.4	2.8	2.2	1.7	1.1	
-20	-28.9	10.7	10.2	8.6	7.5	6.4	5.4	4.3	3.2	2.1	
-10	-23.3	16.7	15.9	13.4	11.7	10	8.4	6.7	5	3.3	
0	-17.8	23.5	22.3	18.8	16.5	14.1	11.8	9.4	7.1	4.7	
10	-12.2	31.3	29.7	25	21.9	18.8	15.7	12.5	9.4	6.3	
20	-6.7	40.8	38.8	32.6	28.6	24.5	20.4	16.3	12.2	8.2	
30	-1.1	51.6	49	41.3	36.1	31	25.8	20.6	15.5	10.3	
40	4.4	63.3	60.3	51.2	45.2	39.2	33.2	27.1	21.1	15.1	3
50	10	77.1	73.6	63.1	56	49	42	35	28	20.9	6.9
60	15.6	92.4	88.4	76.2	68.2	60.1	52	43.9	35.8	27.8	11.6
70	21.1	109	105	90.8	81.6	72.3	63.1	53.9	44.6	35.4	16.9
80	26.7	128	123	107	96.5	86	75.5	65	54.5	43.9	22.9
90	32.2	149	143	125	113	101	89.4	77.5	65.6	53.6	29.8
100	37.8	172	165	145	132	118	105	91.3	77.9	64.4	37.5
110	43.3	197	188	167	152	137	122	106	91.4	76.3	46.1

* HD5, Commercial Grade Propane

BTU content of common fuels		
	Per Pound	Per Gallon
Propane	21,591	91,690
Butane	21,221	102,032
Gasoline	20,930	110,250
Fuel Oil #1	16,960	135,425
Diesel	18,500	142,800

General Information	
1 Lb. Steam	970 BTU
1 Boiler HP (per hr)	33,475 BTU
1 Kilowatt Hour	3,412 BTU
1 Gallon, Water	8.337 lbs
1 Cubic Foot, Water	7.481 gallons
1 Cubic Foot	1,728 cubic inches
1 Gallon	231 cubic inches

Butane Equivalents						
Unit of Measure	BTU	Pound	Therm	Decitherm	Cuft.	Gallon
1 Pound =	21,221	1	0.212	2.12	6.50	0.208
1 Therm =	100,000	4.714	1	10	30.64	0.98
1 Decitherm =	10,000	0.4714	0.1	1	3.06	0.098
1 Cuft. =	3,280	0.1537	0.032	0.32	1	0.03199
1 Gallon =	102,032	4.81	1.02	10.20	31.26	1

Propane Equivalents						
Unit of Measure	BTU	Pound	Therm	Decitherm	Cuft.	Gallon
1 Pound =	21,591	1	0.216	2.16	8.58	0.239
1 Therm =	100,000	4.622	1	10	39.7	1.10
1 Decitherm =	10,000	0.4622	0.1	1	3.97	0.110
1 Cuft. =	2,516	0.1164	0.025	0.25	1	0.027
1 Gallon =	91,690	4.24	0.917	9.17	36.39	1

Atmospheric Pressure at Altitudes

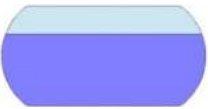

Altitude Above Sea Level (feet)	Altitude Above Sea Level (meters)	Atmospheric Pressure (psi)	Maximum Vacuum Level Attainable (inches Hg)	Vacuum Level Loss at Altitude	Maximum Vacuum Level Possible at this Altitude
0	0	14.70	29.921	0	100%
1000	305	14.16	28.9	3.4%	96.6%
2000	610	13.66	27.8	7.1%	92.9%
3000	914	13.16	26.8	10.4%	89.6%
4000	1219	12.68	25.8	13.8%	86.2%
5000	1524	12.22	24.9	16.8%	83.2%
6000	1829	11.77	24.0	19.8%	80.2%
7000	2134	11.33	23.1	22.8%	77.2%

Vacuum Conversion Table

%Vacuum	inHg (rel)	ft H2O (rel)	Torr (abs) mmHg (abs)	mbar (abs)	psia (abs)	B.P. (°C)	B.P. (°F)
0%	0	0	760	1013.3	14.7	100.0	212.0
10%	2.99	3.39	684	911.7	13.23	97.0	206.6
20%	5.98	6.78	608	810.4	11.76	93.7	200.7
30%	8.98	10.17	532	709.1	10.29	90.1	194.2
40%	11.97	13.56	456	607.8	8.82	86.0	186.8
50%	14.96	16.95	380	506.5	7.35	81.3	178.3
60%	17.95	20.34	304	405.2	5.88	75.6	168.1
70%	20.94	23.73	228	303.9	4.41	68.6	155.5
80%	23.94	27.12	152	202.6	2.94	59.2	138.6
90%	26.93	30.51	76	101.3	1.47	44.2	111.6
91%	27.23	30.85	68.4	91.2	1.32	42.1	107.8
92%	27.53	31.19	60.8	81	1.18	39.7	103.5
93%	27.83	31.53	53.2	70.9	1.03	37.1	98.8
94%	28.13	31.87	45.6	60.8	0.88	34.1	93.4
95%	28.42	32.21	38	50.6	0.73	30.6	87.1
96%	28.72	32.54	30.4	40.5	0.59	26.4	79.5
97%	29.02	32.88	22.8	30.4	0.44	21.2	70.2
98%	29.32	33.22	15.2	20.3	0.29	14.3	57.7
99%	29.62	33.56	7.6	10.1	0.15	2.9	37.2
99.10%	29.65	33.59	6.8	9.1	0.13	1.3	34.3
99.20%	29.68	33.63	6.1	8.1	0.12	-0.5	31.1
99.30%	29.71	33.66	5.3	7.1	0.1	-2.5	27.5
99.40%	29.74	33.7	4.6	6.1	0.09	-4.7	23.5
99.50%	29.77	33.73	3.8	5.1	0.07	-7.3	18.9
99.60%	29.8	33.76	3	4.1	0.06	-10.4	13.3
99.70%	29.83	33.8	2.3	3	0.04	-14.8	5.4
99.80%	29.86	33.83	1.5	2	0.03	-20.2	-4.4
99.90%	29.89	33.87	0.8	1	0.01	-29.0	-20.2
<100%	29.92	33.9	0	0	0		

PRESSURE VESSEL STATS - FILL VOLUMES & SURFACE AREAS

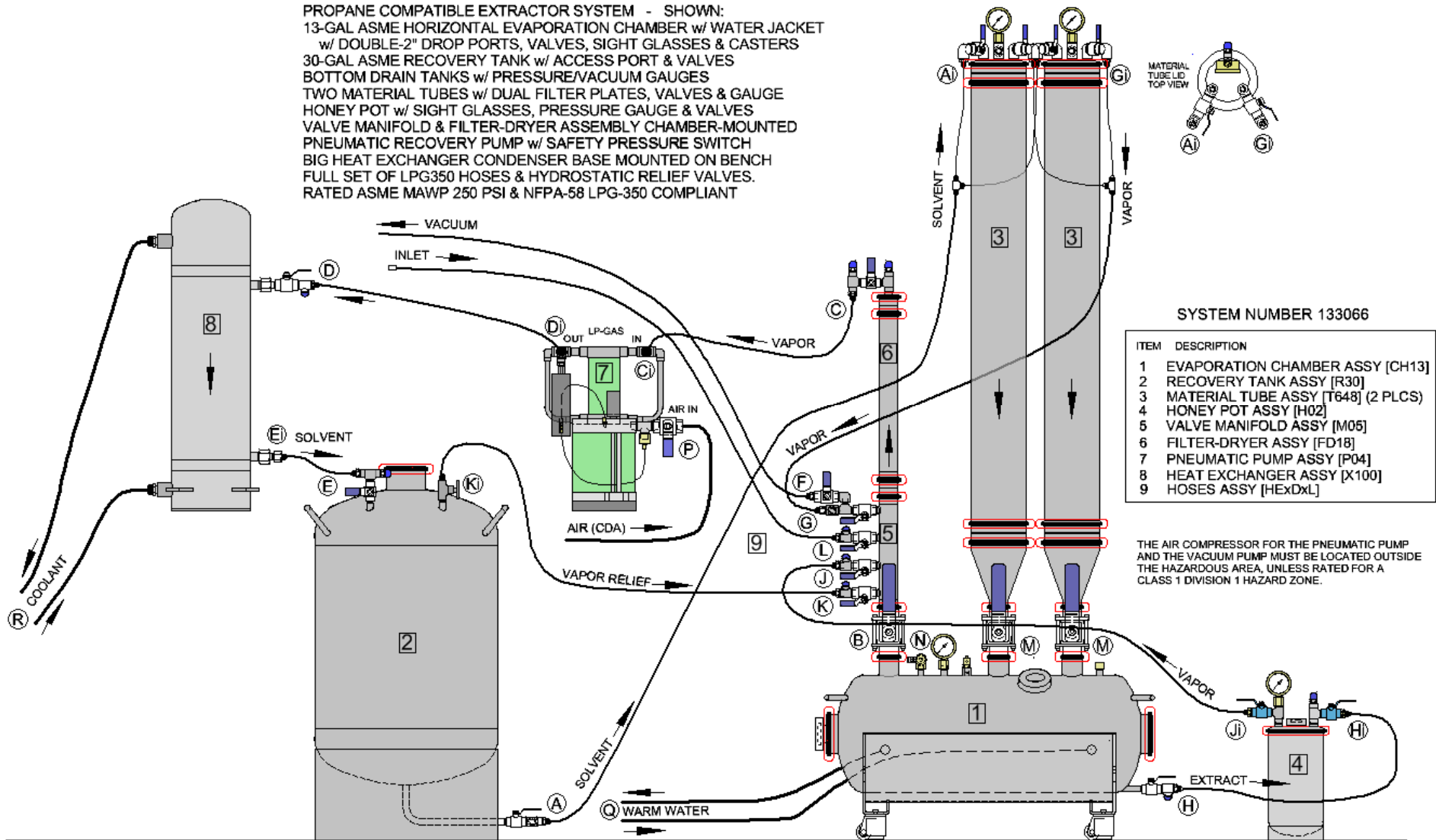
CYLINDRICAL WITH FORMED HEAD EACH END

CONFIGURATION	SHELL SIZE		ACTUAL DIA INSIDE INCH	FLOODED VOLUME GAL	80% FILL VOLUME GAL	AT 80% FILL VOLUME		LIQUID SURFACE AREA @ 50% FULL	
	DIAMETER INCH	LENGTH INCH				BUTANE LBS	PROPANE LBS	SQ.IN.	SHAPE
HORIZONTAL ELLIPSOIDAL HEADS 	6 †	23	5.78	3.0	2.4	12	10	139 #	RECTANGLE PLUS HEADS
	12	26	12.25	16	13	63	56	347 *	
	16	36	15.50	39	31	149	132	649 *	
	24	36	23.50	101	81	389	343	1216 *	
# 5X area of a vertical tank. * 3X area of a vertical tank.									
VERTICAL ELLIPSOIDAL HEADS 	6	12	5.78	1.8	1.4	7	6	26	CIRCLE
	10	12	10.25	6.4	5.1	25	22	83	
	10	36	10.25	15	12	57	51		
	12	12	12.25	9.7	7.8	37	33		
	12	36	12.25	22	18	85	75	118	
	16	36	15.50	39	31	149	132	189	
	20	20	19.50	38	30	147	129	299	
VERTICAL FLAT BOTTOM & FERRULE TOP	6	12	5.78	1.4	1.1	5	5	26	CIRCLE
	10	12	9.73	3.9	3.1	15	13	74	
	12	12	11.73	5.6	4.5	22	19	108	

WARNING: NEVER EXCEED 80% LIQUID FILL VOLUME WITH LPG IN A VESSEL.
ALWAYS HAVE A PROPER SAFETY PRESSURE RELIEF VALVE INSTALLED AND FUNCTIONAL.

CERTIFIED SYSTEM WITH HORIZONTAL CHAMBER

PROPANE COMPATIBLE EXTRACTOR SYSTEM - SHOWN:
 13-GAL ASME HORIZONTAL EVAPORATION CHAMBER w/ WATER JACKET
 w/ DOUBLE-2" DROP PORTS, VALVES, SIGHT GLASSES & CASTERS
 30-GAL ASME RECOVERY TANK w/ ACCESS PORT & VALVES
 BOTTOM DRAIN TANKS w/ PRESSURE/VACUUM GAUGES
 TWO MATERIAL TUBES w/ DUAL FILTER PLATES, VALVES & GAUGE
 HONEY POT w/ SIGHT GLASSES, PRESSURE GAUGE & VALVES
 VALVE MANIFOLD & FILTER-DRYER ASSEMBLY CHAMBER-MOUNTED
 PNEUMATIC RECOVERY PUMP w/ SAFETY PRESSURE SWITCH
 BIG HEAT EXCHANGER CONDENSER BASE MOUNTED ON BENCH
 FULL SET OF LPG350 HOSES & HYDROSTATIC RELIEF VALVES.
 RATED ASME MAWP 250 PSI & NFPA-58 LPG-350 COMPLIANT



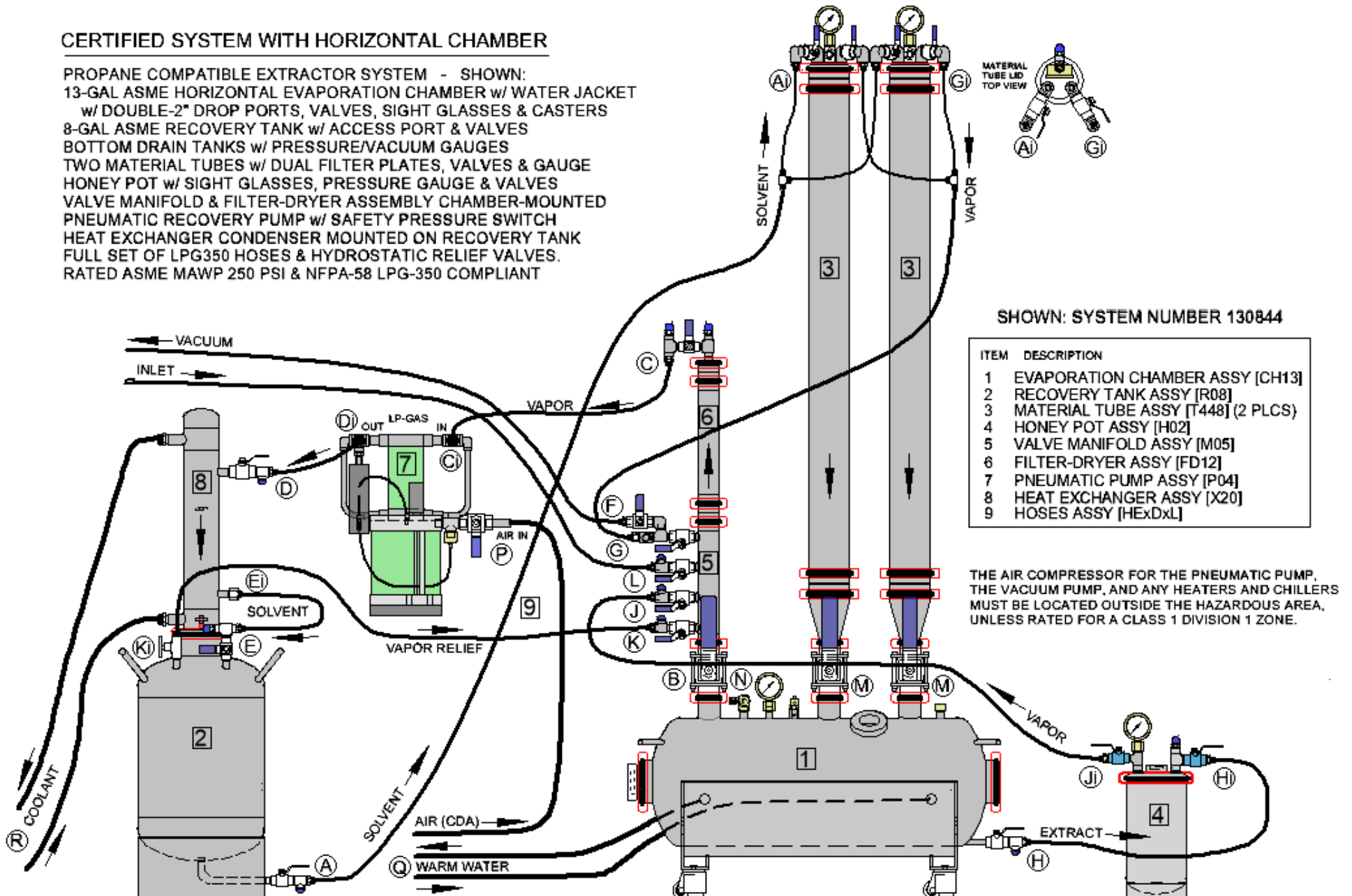
SYSTEM NUMBER 133066

ITEM	DESCRIPTION
1	EVAPORATION CHAMBER ASSY [CH13]
2	RECOVERY TANK ASSY [R30]
3	MATERIAL TUBE ASSY [T648] (2 PLCS)
4	HONEY POT ASSY [H02]
5	VALVE MANIFOLD ASSY [M05]
6	FILTER-DRYER ASSY [FD18]
7	PNEUMATIC PUMP ASSY [P04]
8	HEAT EXCHANGER ASSY [X100]
9	HOSES ASSY [HExDxL]

THE AIR COMPRESSOR FOR THE PNEUMATIC PUMP AND THE VACUUM PUMP MUST BE LOCATED OUTSIDE THE HAZARDOUS AREA, UNLESS RATED FOR A CLASS 1 DIVISION 1 HAZARD ZONE.

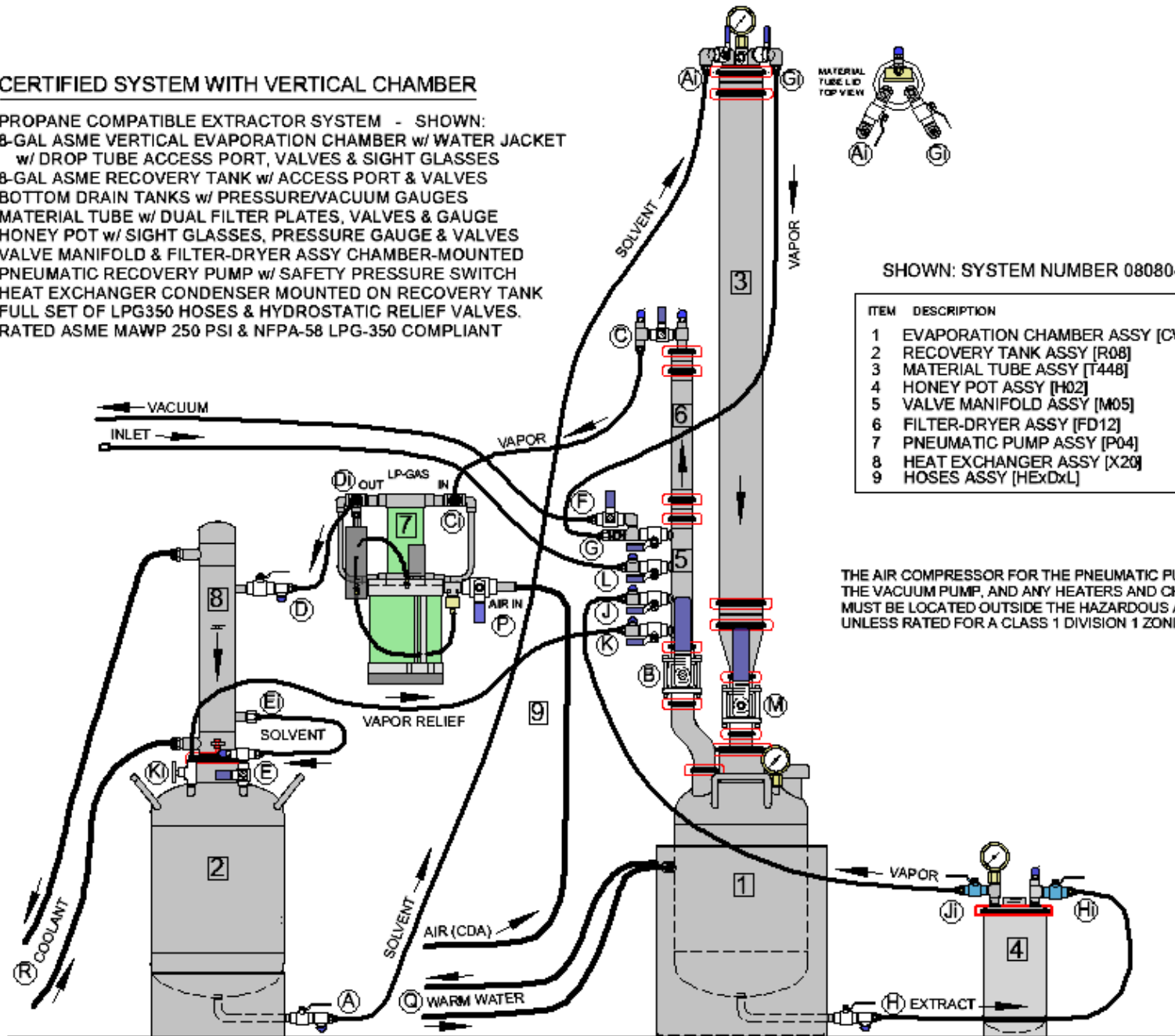
CERTIFIED SYSTEM WITH HORIZONTAL CHAMBER

PROPANE COMPATIBLE EXTRACTOR SYSTEM - SHOWN:
 13-GAL ASME HORIZONTAL EVAPORATION CHAMBER w/ WATER JACKET
 w/ DOUBLE-2" DROP PORTS, VALVES, SIGHT GLASSES & CASTERS
 8-GAL ASME RECOVERY TANK w/ ACCESS PORT & VALVES
 BOTTOM DRAIN TANKS w/ PRESSURE/VACUUM GAUGES
 TWO MATERIAL TUBES w/ DUAL FILTER PLATES, VALVES & GAUGE
 HONEY POT w/ SIGHT GLASSES, PRESSURE GAUGE & VALVES
 VALVE MANIFOLD & FILTER-DRYER ASSEMBLY CHAMBER-MOUNTED
 PNEUMATIC RECOVERY PUMP w/ SAFETY PRESSURE SWITCH
 HEAT EXCHANGER CONDENSER MOUNTED ON RECOVERY TANK
 FULL SET OF LPG350 HOSES & HYDROSTATIC RELIEF VALVES.
 RATED ASME MAWP 250 PSI & NFPA-58 LPG-350 COMPLIANT



CERTIFIED SYSTEM WITH VERTICAL CHAMBER

PROPANE COMPATIBLE EXTRACTOR SYSTEM - SHOWN:
 8-GAL ASME VERTICAL EVAPORATION CHAMBER w/ WATER JACKET
 w/ DROP TUBE ACCESS PORT, VALVES & SIGHT GLASSES
 8-GAL ASME RECOVERY TANK w/ ACCESS PORT & VALVES
 BOTTOM DRAIN TANKS w/ PRESSURE/VACUUM GAUGES
 MATERIAL TUBE w/ DUAL FILTER PLATES, VALVES & GAUGE
 HONEY POT w/ SIGHT GLASSES, PRESSURE GAUGE & VALVES
 VALVE MANIFOLD & FILTER-DRYER ASSY CHAMBER-MOUNTED
 PNEUMATIC RECOVERY PUMP w/ SAFETY PRESSURE SWITCH
 HEAT EXCHANGER CONDENSER MOUNTED ON RECOVERY TANK
 FULL SET OF LPG350 HOSES & HYDROSTATIC RELIEF VALVES.
 RATED ASME MAWP 250 PSI & NFPA-58 LPG-350 COMPLIANT



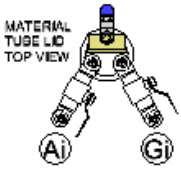
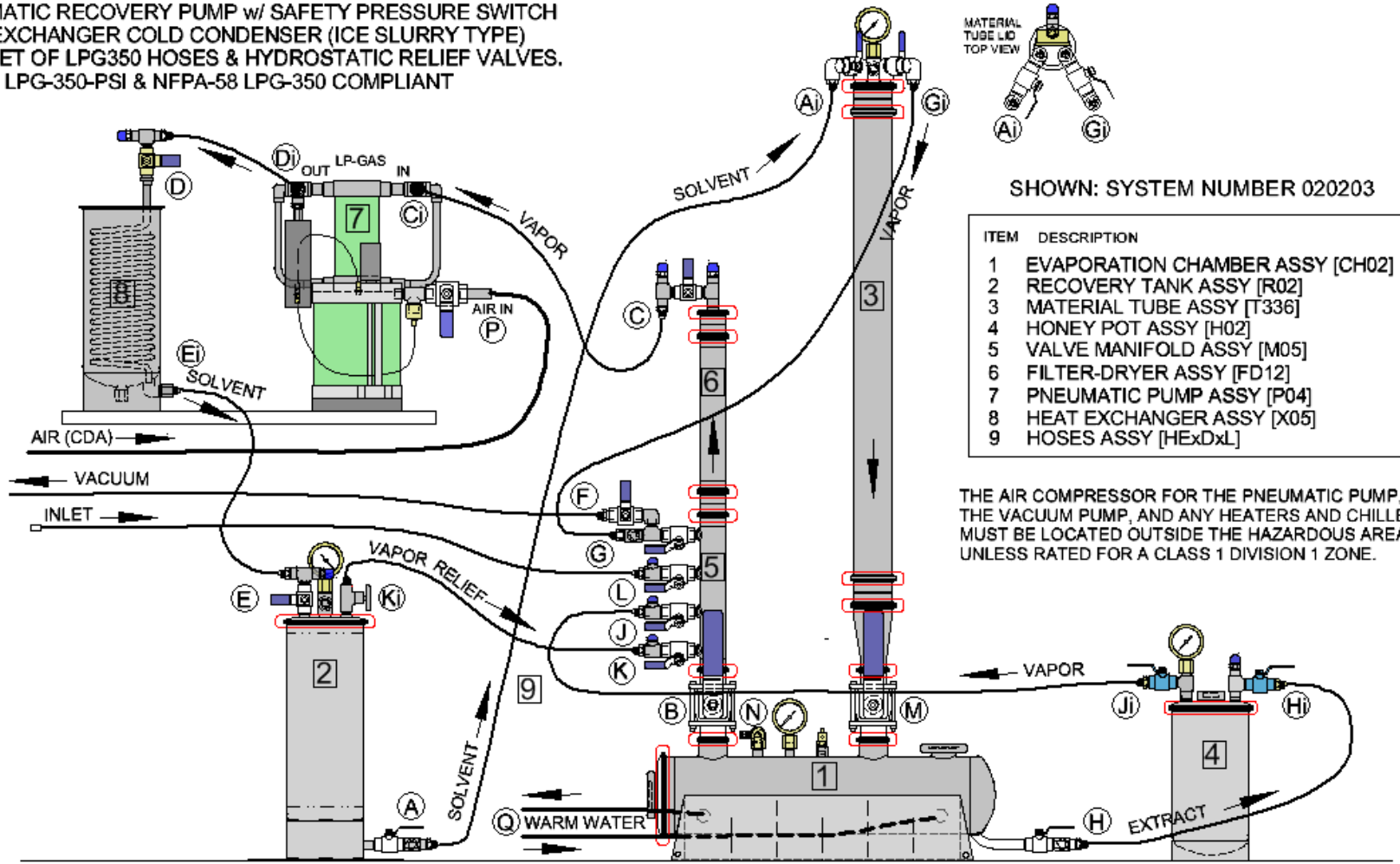
SHOWN: SYSTEM NUMBER 080804

ITEM	DESCRIPTION
1	EVAPORATION CHAMBER ASSY [CV08]
2	RECOVERY TANK ASSY [R08]
3	MATERIAL TUBE ASSY [T448]
4	HONEY POT ASSY [H02]
5	VALVE MANIFOLD ASSY [M05]
6	FILTER-DRYER ASSY [FD12]
7	PNEUMATIC PUMP ASSY [P04]
8	HEAT EXCHANGER ASSY [X20]
9	HOSES ASSY [HEXDXL]

THE AIR COMPRESSOR FOR THE PNEUMATIC PUMP, THE VACUUM PUMP, AND ANY HEATERS AND CHILLERS MUST BE LOCATED OUTSIDE THE HAZARDOUS AREA, UNLESS RATED FOR A CLASS 1 DIVISION 1 ZONE.

CERTIFIED SYSTEM WITH HORIZONTAL CHAMBER

PROPANE COMPATIBLE EXTRACTOR SYSTEM - SHOWN:
 2.4-GAL LPG-350 HORIZONTAL EVAPORATION CHAMBER w/ WATER JACKET, ACCESS LID, 2" DROP PORT, VALVES & SIGHT GLASSES
 2-GAL LPG-350 RECOVERY TANK w/ ACCESS LID & VALVES
 BOTTOM DRAIN TANKS w/ PRESSURE/VACUUM GAUGES
 MATERIAL TUBE w/ DUAL FILTER PLATES, VALVES & GAUGE
 HONEY POT w/ SIGHT GLASSES, PRESSURE GAUGE & VALVES
 VALVE MANIFOLD & FILTER-DRYER ASSEMBLY CHAMBER-MOUNTED
 PNEUMATIC RECOVERY PUMP w/ SAFETY PRESSURE SWITCH
 HEAT EXCHANGER COLD CONDENSER (ICE SLURRY TYPE)
 FULL SET OF LPG350 HOSES & HYDROSTATIC RELIEF VALVES.
 RATED LPG-350-PSI & NFPA-58 LPG-350 COMPLIANT



SHOWN: SYSTEM NUMBER 020203

ITEM	DESCRIPTION
1	EVAPORATION CHAMBER ASSY [CH02]
2	RECOVERY TANK ASSY [R02]
3	MATERIAL TUBE ASSY [T336]
4	HONEY POT ASSY [H02]
5	VALVE MANIFOLD ASSY [M05]
6	FILTER-DRYER ASSY [FD12]
7	PNEUMATIC PUMP ASSY [P04]
8	HEAT EXCHANGER ASSY [X05]
9	HOSES ASSY [HExDxL]

THE AIR COMPRESSOR FOR THE PNEUMATIC PUMP, THE VACUUM PUMP, AND ANY HEATERS AND CHILLERS MUST BE LOCATED OUTSIDE THE HAZARDOUS AREA, UNLESS RATED FOR A CLASS 1 DIVISION 1 ZONE.

CERTIFIED SYSTEM WITH VERTICAL CHAMBER

PROPANE COMPATIBLE EXTRACTOR SYSTEM - SHOWN:
 8-GAL ASME VERTICAL EVAPORATION CHAMBER
 w/ DROP TUBE ACCESS PORT, VALVES & SIGHT GLASSES
 8-GAL ASME RECOVERY TANK w/ ACCESS PORT & VALVES
 DIPTUBE OUTLET TANKS w/ PRESSURE/VACUUM GAUGES
 MATERIAL TUBE w/ DUAL FILTER PLATES, VALVES & GAUGE
 HONEY POT w/ SIGHT GLASSES, PRESSURE GAUGE & VALVES
 VALVE MANIFOLD & FILTER-DRYER ASSY STAND-MOUNTED
 PNEUMATIC RECOVERY PUMP w/ SAFETY PRESSURE SWITCH
 HEAT EXCHANGER CONDENSER MOUNTED ON STAND
 FULL SET OF LPG350 HOSES & HYDROSTATIC RELIEF VALVES.
 RATED ASME MAWP 250 PSI & NFPA-58 LPG-350 COMPLIANT

THE MANIFOLD & FILTER-DRIER ASSEMBLY MAY BE
 MOUNTED DIRECTLY ONTO THE CHAMBER USING
 AN ADAPTER AND LARGE VALVE.

SHOWN: SYSTEM NUMBER 8D8D04

ITEM	DESCRIPTION
1	EVAPORATION CHAMBER ASSY [CV8D]
2	RECOVERY TANK ASSY [R8D]
3	MATERIAL TUBE ASSY [T448]
4	HONEY POT ASSY [H02]
5	VALVE MANIFOLD ASSY [M05]
6	FILTER-DRYER ASSY [FW12]
7	PNEUMATIC PUMP ASSY [P04]
8	HEAT EXCHANGER ASSY [X20R]
9	HOSES ASSY [HExDxL]
10	STAND ASSY [S01]

THE AIR COMPRESSOR FOR THE PNEUMATIC PUMP
 AND THE VACUUM PUMP MUST BE LOCATED OUTSIDE
 THE HAZARDOUS AREA, UNLESS RATED FOR A
 CLASS 1 DIVISION 1 HAZARD ZONE.

