Building a Safer Butane Hash Oil Extraction Facility

An Industrial Hygiene Perspective

May 2014

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Maybe you are an ambitious new entrepreneur. Medical marijuana is now legal in your state. Maybe even recreational marijuana is legal. You have just purchased a shiny new butane closed-loop extraction system and that system may have received an engineer’s review as being safe. You have a stock of trim or premium bud to process. You are going to make thousands of dollars of hash oil, shatter, or butter every day. You are ready to go, right? Wrong.

In Colorado, the use of closed-loop systems that recover butane and prevent it from being released to the environment are the only systems that meet regulatory standards. Although a closed-loop system by itself significantly reduces risks to operators, the installation and operation of such systems can also result in hazards. This brochure is intended to look at some techniques that have been used to reduce the hazards of use of these systems in buildings.

Developing a safer installation can be a complex task, with a number of factors to consider.

Many of these measures are part of a belt-and-suspenders system – so that if your belt fails, your suspenders are still there to keep you from getting embarrassed. Only with butane you risk more than embarrassment – your life or your employee’s lives are on the line.

In the United States, the chemical process industry has an excellent safety history. Operating a butane closed-loop system is a complex industrial process. If you start up your system without addressing the installation safety hazards, you are not going to get close to the existing industry safety experience. You are likely to get shut down by some regulator from any one of the many agencies looking over your shoulder. To be not only the ambitious entrepreneur, but the successful one, you need to not only pay attention to safety and compliance, you have to plan for it.

**SOME FACTORS FOR CONSIDERATION**

- Room Dilution Ventilation
- Fire and Life Safety Systems
- Airflow Pathways, Exchange Rates, and Velocities
- Local Area Exhaust Ventilation
- Interior and Exterior Storage of Flammable Solvents
- Ignition Source Control
- Flammable Gas Monitoring
- Training
- Personal Protective Equipment
- Hazardous Materials Management
- Sanitation
- Fire and Emergency Management
I. COST CONSIDERATIONS – PROPER INSTALLATION CAN BE EXPENSIVE

The proper installation of a closed-loop hash oil extraction system (“CL System”) can be expensive and time-consuming. When the costs of a properly installing a CL System for safer operation are counted up, those costs can easily exceed the costs of the extraction system itself.

COST FACTORS TO CONSIDER WHEN SETTING UP A CLOSED-LOOP BUTANE EXTRACTION SYSTEM

- Purchase and installation of a proper ventilation system
- Updating and improving room layout
- Finishing room flooring, walls and ceilings with cleanable surfaces
- Certified Industrial Hygienist or Professional Engineer review and support
- Training program development and implementation
- Spark-less Tools
- Electrical upgrades
- Reduction of spark and ignition hazards
- Flammable Gas Detection Instruments
- Signage
- Personal Protective Equipment
- Butane Storage Cages
- Sprinkler System Installation
- Fire Extinguisher Purchase & Maintenance

This document is not intended to assess the function, safety, or engineering of any particular closed-loop hash oil extraction system. Rather, it is intended to inform users of the installation and use of such systems in industrial or commercial operations in a manner that may reduce risk.
II. VENTILATION – REMOVING FLAMMABLE GAS

A Closed-Loop Butane Extraction System (“CL System”) can capture most of the butane used to extract hash oil. Some butane will escape. Loose fittings, cracks in tubing, operator error, or even emptying spent trim from the extraction vessel will cause some butane to escape. The Closed-Loop System itself is significantly safer than open blasting as it is intended to capture butane rather than automatically releasing it to the atmosphere. Capturing and exhausting butane when it is released by a leak, spill, error, or operation is the purpose of the ventilation system.

The goal of the ventilation system is to keep the concentration of butane in the operating area low enough to be well below the concentration at which it can ignite or explode. The Lower Explosive Limit (LEL) is the minimum amount of butane in air that can ignite or explode. For butane, the LEL is approximately 1.6 percent in air.

The Canadian Centre for Occupational Health and Safety has an excellent web page that discusses industrial ventilation at [http://www.ccohs.ca/oshanswers/prevention/ventilation/](http://www.ccohs.ca/oshanswers/prevention/ventilation/). The ventilation example images used here and selected text are from the CCOHS website.

**Local exhaust ventilation** captures gases such as butane at their source by placing the working system inside a hood to capture gases as they are released.

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**TWO TYPES OF MECHANICAL VENTILATION SYSTEMS USED IN INDUSTRIAL SETTINGS**

**Dilution (or general) ventilation** reduces the concentration of the contaminant by mixing the contaminated air with clean, uncontaminated air.

**Local exhaust ventilation** captures contaminants at or very near the source and exhausts them outside.

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*Figure 1. Local Exhaust Ventilation Hood*
Local exhaust ventilation has advantages in that a relatively small amount of air is exhausted to capture the contaminant.

**Dilution Ventilation** uses general room supply and exhaust to dilute the contaminant even if it has left the vicinity of the extraction system. Dilution systems can take many configurations and some examples from the CCOHS are reproduced here. Dilution requires large amounts of air supply to keep concentrations low.

Generally, dilution ventilation systems should be constructed to move air across the room rather than having both supply and exhaust near each other. The exhaust should be near the work. Butane is heavier than air, so having both low and high supply and exhaust locations may be recommended.

![Figure 2. Dilution Ventilation Low Ducted Supply](image1)

![Figure 3. Unacceptable Dilution Ventilation Configuration](image2)
Ventilation systems are mandatory for CL Systems. Without ventilation, even a small leak or release of butane can quickly approach explosive levels.

Fans and motors used in ventilation systems should be explosion-proof. The use of a manufactured paint spray booth can meet many of the ventilation and explosion-proof system requirements when used for a butane extraction system. Manufactured paint spray booths are supplied with explosion-proof ventilation and lighting. **A butane extraction system placed into a vented, manufactured paint spray booth may more easily meet fire department, industrial hygiene or engineering requirements.** Fan speed and volume flow must be adjusted to the specific installation.

CL System work areas should be kept free of clutter and unnecessary equipment or materials. Unneeded objects can easily disrupt air flow and create potential eddies where flammable gas could accumulate.

### III IGNITION PREVENTION – REMOVE EXPLOSIVE TRIGGERS

Ventilation reduces the potential for gas to be present in concentrations above the Lower Explosive Limit. Since systems and humans are not often perfect, we need to reduce the potential for ignition of butane if the LEL is exceeded due to unexpected release, errors, or accidents.

**Electrical equipment** can often provide ignition sources. The number of electrical outlets, switches, light fixtures and equipment in the area of the Closed-Loop Extraction System should be kept to a minimum. When possible, place electrical switches outside of the CL System area. Light fixtures should be placed out of the path of work and traffic to prevent breaking the fixture or lamp. Circuits should be ground-fault protected.

If a large (more than 30 gallons of butane are present at any one time) CL System is in use, additional precautions and systems may be necessary. **Explosion proof electrical fixtures, rated fire walls and doors, sprinkler systems, and other special building components are required by building codes for high-hazard areas.**

Hand tools such as corded or battery tools can be ignition sources. **Electric hand tools should be prohibited** from use during operation of a CL System.

Tools used directly on CL Systems such as wrenches or screwdrivers should be made of non-sparking materials. The opening of extraction vessels can produce micro-environments where the LEL is exceeded. **Non-sparking tools** can help to reduce risks of ignition around leaking fittings and equipment.
Pilot lights on water heaters, area heaters, stoves, furnaces or other gas-fueled appliances can be a source of ignition for butane. Since butane is heavier than air, and cools when it evaporates, it can easily form a layer of flammable gas over a floor. When that flammable gas layer reaches a pilot light, explosions will occur. Do not place CL Systems in rooms or areas near any equipment with pilot lights.

Static can be a hazard around CL Systems. The use of anti-static mats at CL Systems may reduce risks from static-created sparks. Keeping light switches out of work areas and grounding of equipment may reduce risks.

Some people have claimed that the flow of liquid butane through polypropylene tubing or vessels may create a static electricity charge, possibly providing an ignition source. Avoid polypropylene materials on a CL System.

Smoking of any substance is prohibited around CL Systems. This includes the product that is created in your CL System. Post flammable gas and no-smoking signs in and around work areas.

IV GAS DETECTION AND MONITORING

Butane is a colorless and nearly odorless gas, particularly at the low concentrations needed to form explosive mixtures in air. Unlike natural gas, no odorant is added to give the gas a warning smell. When butane concentrations rise to the levels where you can first detect an odor, the concentration is already near the lower explosive limit. If you can smell butane in your work area you need to immediately stop work, shut down your equipment, maintain active ventilation, and figure out where a leak or release is occurring.

Because you cannot smell butane until it is at dangerous concentrations, gas detection and monitoring devices are needed for your protection. Several types of detection equipment are used. These include fixed, in-place area instruments that continuously monitor for dangerous levels of flammable gas and hand-held portable instruments that detect flammable gas. Instruments may provide a readout that shows a percentage of the Lower Explosive Limit (“LEL”) or may simply provide warning clicks or tones to indicate increasing concentrations of gas.

Area gas monitoring systems typically report readings in percentages of the LEL. They are often set to alarm at different levels and may be set to close valves or shut down equipment at a set percentage of the LEL. Area systems may have more than one gas detector with detectors located in different parts of the work area. Often, one detector is located at the CL System to give immediate warning of a leak. A second detector can be located in the general work area around the CL System to indicate overall room concentrations. Sometimes detectors can also be placed at the exhaust ventilation port for the work area. Monitoring systems should be set to alarm at five percent of the LEL and shut down valves at ten percent of the LEL.
Some butane closed-loop systems are built with area gas detection systems as an integral part of the equipment. If a CL System is installed that does not have an integrated gas detection system, a separate continuous area monitoring system must be installed. **Without a continuous area monitoring system, a leak or release may go undetected with risk of serious injury or death.**

A hand-held flammable gas detector is used to check area levels of flammable gas and is very useful for detecting small leaks from a CL System. **Every operator of a CL System should own and use a hand-held flammable gas detector to check for leaks on a daily basis.**

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**CALIBRATION IS IMPORTANT**

Many gas detection systems are calibrated to gases other than butane. The detectors respond differently to different gases. Most systems are calibrated to methane (natural gas). If your detector was calibrated to methane and you are using butane, the LEL reading you see will be significantly low. If your methane-calibrated meter reads 10% LEL around your butane, you are really at 20% of the LEL of butane. Thus, when your meter reads 50% LEL, you already have an explosive atmosphere. Know and understand your instrument calibrations and get them recalibrated on a regular basis. Set the zero reading for your meter in a clean area well away from your CL System.

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*Figure 6. Flammable Gas Detector*
V  BUTANE STORAGE AND MANAGEMENT

Purchasing, storing and moving butane is more complicated than it seems. First, operators of a butane closed-loop systems need to understand what butane is, what varieties of butane exist, how butane is graded, and what the properties of butane are.

**BUTANE CHEMISTRY**

\[ \text{n-Butane has four carbon atoms connected in single file and ten hydrogen atoms (C}_4\text{H}_{10}. \text{n-Butane is the solvent used by most CL Systems. Iso-Butane is also C}_4\text{H}_{10}, but the carbon atoms are connected in a “T”. This changes the properties significantly.} \]

At room temperature n-Butane has a pressure of about 20-25 psi and at 32°F, the pressure is almost zero psi. Iso-Butane has higher pressures at room temperature and at 32°F.

Many CL System operators prefer to use n-butane due to its lower operating pressure and its very low vapor pressure at the freezing point of water. Some CL Systems use the differences between room temperature and freezing to recover the n-butane.

n-Butane is also known as “normal” butane which is usually 99% pure. Instrument grade or pharmaceutical grade gas may be 99.5% pure. In order to receive iso-butane (which you probably do not want anyway), you must specify that to the supplier.

**NEVER FILL A BUTANE BOTTLE MORE THAN 2/3 FULL WITH LIQUID**

Expansion space is needed since butane liquid expands as temperature increases.
Whenever possible, store your extra stock of butane outside your building in a secure, locked cage. Limit the quantity of butane in the building to 30 gallons or less unless you have specially designed buildings and settings for your system. Place bollards in front of cages if vehicles could strike the cage.

**VI TRAINING IS ESSENTIAL**

If you have read this far, you are aware that the use of butane in industrial settings has many dangers. Allowing an untrained person to operate a butane closed-loop extraction system will increase risks to everyone involved.

Training programs must be provided by a live in-person instructor. Computer-based training programs or e-seminars are not sufficient according to State of Colorado regulations.

*Training programs must be thoroughly documented including:*

- Training Outline/Agenda
- Date(s) of Training
- Trainer Name
- Record attendees and their MED identification numbers
- Signed statement attesting that each trainee knows and understands the material and can operate a butane extraction system in a safe manner
- All CL System operators AND the Owner/Key Operator must complete the training.
VII PERSONAL PROTECTIVE EQUIPMENT

One of the first principles of safety and industrial hygiene is to first set up and systems that keep hazards away from workers. Most of this document focuses on establishing such systems that keep workers safe without active attention.

Unfortunately, butane is an extremely flammable gas and fire and explosions will sometimes occur in butane closed-loop extraction systems facilities. Even in the best-run operations, an oversight, a moment of inattentiveness, or failure of a seal or fitting and result in incidents. Personal protective equipment is necessary to help protect workers and visitors for those occasions when problems occur.

**SAFETY GLASSES ARE MANDATORY**
Operating or visiting a butane extraction system can place a person in harm’s way. The use of safety glasses is a standard throughout industrial production systems and hash oil workers should not be exempt.

The owner should pay for safety glasses, install signs requiring their use, and keep a bin of safety glasses next to the entrance to the CL System area.

Prescription glasses are usually NOT safety glasses. Safety glasses can be purchased that fit over prescription glasses.

Full-length pants, closed-top shoes and long sleeves should be worn at all times in the CL System area. Clothing should be made of fabric with a tight weave that can help resist ignition. Laboratory coats are ideal wear for CL System areas. Long hair should be worn up, under a hat (again-tight weave fabric).

*Eyewash stations must be installed* in the work area of the butane closed loop extraction system according to Colorado Law. Plumbed systems with automatic temperature control systems built in are best. Place the eyewash station in the room where a temporarily blinded worker can still find it.
VIII  SANITATION

The manufacture of butane hash oil requires that food-grade sanitary measures be used. Avoiding clutter, regular disinfection of surfaces, periodic deep cleaning, and personal hygiene are all involved.

Make sure that signs requiring employees to wash hands are posted in each restroom and each area sink.

Employers have an obligation to enforce the hand-washing rules.

Wiping down of all working surfaces with commercially available disinfectant is required at least on a daily basis. Floors must be mopped with cleaning solution on a daily basis.

Deep cleaning of all equipment and surfaces is required at least on a weekly basis.

Pyrex dishes and utensils used for drying or whipping of wax must be thoroughly washed between each use.

Floors, walls and ceilings must have cleanable surfaces. Use of plastic milk-board on walls and ceilings is recommended. Tile flooring is recommended. Carpeting is unsuitable for operation of a CF System.
Part of an effective safety program is to have systems and procedures in place to respond when bad things happen. Several items can help businesses and workers deal with emergencies on a more effective basis.

Every facility with a closed-loop butane extraction system should have a written emergency response plan. Even a brief plan will help an organization prepare for and deal with emergencies.

The route to the nearest emergency room should be mapped out and posted near the CL System room. A copy of the map should be kept with the emergency response plan.

The plan should include a portion on building evacuation. How will you notify people to evacuate? Where will they gather? Who notifies the Fire Department? How do you make sure everyone is out of the building? Answering these questions and writing down the answers will save lives.

**SPRINKLER SYSTEMS**
Everyone involved with Safety loves building sprinkler systems. They save lives and dramatically reduce property damage. While sprinkler systems are expensive, they can easily be cheaper over the life cycle of a building.

Even a small sprinkler system limited to the area of the closed-loop butane extraction system is preferable to none at all.

**LEAK AND SPILL RESPONSE**
If a monitoring device detects a leak:

- Close valves to all tanks
- Continue vent to outside
- Shut down vacuum/recovery pump
- Turn off heat to buckets
- Remove buckets from hot water
EMERGENCY PROCEDURES - FIRE

- Sound Alarm – Notify Others
- Call 911
- Evacuate area
- Use ABC rated fire extinguishers
- Use extinguishers only for small fires
- To assist escape
- To assist people
- Aim at base of fire
- If you need a second extinguisher – evacuate instead

X MATERIAL SAFETY DATA SHEETS & HAZARD COMMUNICATION

Butane is a hazardous chemical product and butane closed-loop extraction system businesses must have a Material Safety Data Sheet from the manufacturer on site at all times. However, an MSDS is only part of a Hazard Communication Program. Failure to have and follow a written Hazard Communication Program is the number one general industry compliance problem cited by the Occupational Safety and Health Administration (OSHA).

Link to AIRGAS n-Butane MSDS
**STEPS TO AN EFFECTIVE HAZARD COMMUNICATION PROGRAM**

1. Learn the Standard/Identify Responsible Staff
2. Prepare and Implement a Written Hazard Communication Program
3. Ensure Containers are Labeled
4. Maintain Safety Data Sheets
5. Inform and Train Employees
6. Evaluate and Reassess Your Program

*From: [https://www.osha.gov/Publications/OSHA3695.pdf](https://www.osha.gov/Publications/OSHA3695.pdf)

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**XI EQUIPMENT AND INSTALLATION REVIEW AND CERTIFICATION**

The Colorado Marijuana Enforcement Division requires that all butane closed-loop extraction systems and installations be professionally reviewed. Section D of R 605 –Retail Marijuana Products Manufacturing Facility: Retail Marijuana Concentrate Production and Section D of M605 - M 605 – Medical Marijuana-Infused Products Manufacturer: Medical Marijuana Concentrate Production list these requirements in detail.

**CLOSED LOOP EXTRACTION SYSTEM LISTING OR REVIEW**

*Every professional grade, closed-loop extraction system capable of recovering the solvent used to produce Solvent-Based Medical Marijuana Concentrate must obtain:*

a. UL or ETL Listing
b. Non-listed solvents for an extraction device requires approval by the manufacturer or a Professional Engineer
c. If not UL or ETL Listed, there must be a designer of record and the extraction device must be “peer reviewed” by a Professional Engineer.
A Colorado Marijuana-Infused Products Manufacturer that engages in the production of Solvent-Based Marijuana Concentrate must obtain a report from a Certified Industrial Hygienist or a Professional Engineer that certifies that the equipment, Licensed Premises and standard operating procedures comply with these rules and all applicable local and state building codes, fire codes, electrical codes and other laws.

The reports are due July 1, 2014.

LOCAL FIRE DEPARTMENT

DO NOT START YOUR EXTRACTOR UNTIL YOU HAVE CONTACTED YOUR LOCAL FIRE MARSHALL

Your Fire Department has the authority to inspect buildings, fire hazards, equipment installations, and prevention measures. Your Fire Department may require a permit for the use of flammable gases inside of buildings.

Keep your life simpler and work with your Fire Marshall from the start.
XII OPEN BLASTING IS DANGEROUS, STUPID AND ILLEGAL

The use of Butane Hash Oil (BHO) extraction systems has been increasing rapidly in Colorado and other states. In the underground markets, the use of open blasting through a tube such as is pictured here seems to be the method usually chosen.

Open blasting is where a canister of butane is emptied through a tube filled with marijuana. The liquid mixture of butane and hash oil is then collected in a dish. **Open blasting is inherently dangerous.**

- In Colorado alone, during the first four months of the 2014, firefighters in the state have raced to at least 31 butane hash oil explosions. The use of open blasting is causing a large number of injuries and significant property damage.
- The open, unregulated release of butane into the atmosphere is itself against the law. Fire and Police Departments are not friendly to users of this type of equipment.
- Users have faced arson and numerous other charges from using these systems.
- Owners and managers at a marijuana grow operation (even legal ones) that instruct employees to use open blasting techniques may face criminal charges.

If your business is relying on the use of open blasting for production of hash oil you need to STOP BLASTING IMMEDIATELY! One incident, fire, explosion, inspection or burn...and your entire entrepreneurial accomplishments will be gone. **Do not open blast. Do not think about doing it.**

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*It is in the interest of the newly legal, legitimate industry that uses properly installed closed loop to stop everyone from open blasting. If you own or run a retail operation, stop selling blasting tubes and cans of butane. They may come back to burn you.*
XIII  CHECKLIST – ITEMS FOR CONSIDERATION

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<td>Extraction Room Identification</td>
<td></td>
</tr>
<tr>
<td>Route to Nearest Emergency Room</td>
<td></td>
</tr>
</tbody>
</table>