Cannabis/Hemp Extraction Equipment

Relevant Codes, Good Engineering Practice and Approval

Introduction

John R. Andrzejczak, PE

CO, ID, MD, PA, & WA

- First of a Kind, One of a Kind Custom Equipment Design
- ASME NQA-1 and B&PV Quality Programs
- ASME B&PV Code
- cGMP Pharmaceutical Equipment
- Hazard and Safety Analysis
- Installation and Start-Up
- Factory and Site Testing

Prior experience in chemical, petrochemical, nuclear, and pharmaceutical industries.

Introduction

- Pressure Safety Inspectors
  - Performed ~100 engineering peer reviews (3rd party design verifications) on extraction equipment
  - Reviewed 300+ extraction facilities in California, Colorado, Nevada, Oregon, and Washington
  - Performed hundreds of equipment field verifications
  - Started working in this industry in February of 2014
- Headquartered in Colorado

  5460 Montana Vista Way

  Suite 101

  Castle Rock, CO 80108

  303-317-6877

OBJECTIVES

Course Objectives

- Understand the following:
  - Hazards Associated with Extraction
  - Codes & Standards
  - Equipment Approval Process

PROCESSING HAZARDS

Hazards

- Extraction Equipment
  - Water Based (no significant hazards)
  - Solvent Based Extraction
    - Butane (LPG)
    - Propane (LPG)
    - Carbon Dioxide (CO_2)
    - Ethanol
    - Purge Gases
    - Carbon Dioxide (CO_2) in use other than solvent
    - Others

Hazards – Solvent Based Extraction Equipment

- Butane (LPG)
  - Could be n-butane or iso-butane
  - Vapor pressure up to 100 psig @100°F (piping designed for 350 psig)
  - Temperature typically from -20°F to 125°F
    - Could be as low as -110˚F
  - Typical Quantity 10 lbs to 50 lbs of LPG

Hazards – Solvent Based Extraction Equipment

- Propane (LPG)
  - Vapor pressure up to 250 psig @100°F (piping designed for 350 psig)
  - Can also run Butane in the system
  - Temperature typically from -20°F to 125°F
    - Could be as low as -110˚F
  - Quantity 10 lbs to 50 lbs of LPG

Hazards – Solvent Based Extraction Equipment

- LPG
  - Low Pressure
  - Asphyxiation
  - Explosion/Fire
  - Contact with Eyes/Skin
  - Low Temperature (freezes skin on contact)
  - Unscented

Hazards – Solvent Based Extraction Equipment

- Butane only Equipment
  - Significantly lower vapor pressure therefore system is designed to operate below 100 psig @100°F with pressure reliefs set at around 130 psig
  - Propane and Propane mixtures can not be used with this equipment due to higher vapor pressures
    - The vapor pressure of Propane at 100°F is 172 psig
    - While the equipment is protected by pressure relief valves, hydrocarbons will be released into the room if propane is used

Hazards – Solvent Based Extraction Equipment

- Carbon Dioxide (CO_2)
  - Very High Pressure
  - Asphyxiation
  - Contact with Eyes/Skin
  - Temperatures

Hazards – Solvent Based Extraction Equipment

- Carbon Dioxide (CO_2) (not as a solvent)
  - May be used to cool through Joule-Thomson effect
    - The Joule-Thomson effect describes the temperature change of a liquid when it is forced through a valve or porous plug while kept insulated so that no heat is exchanged with the environment. This procedure is called a throttling process or Joule–Thomson process. **The throttling process is commonly exploited in thermal machines such as refrigerators, air conditioners, heat pumps, and liquefiers.**
  - Dry Ice baths (Cooling Baths)
    - Dry Ice in a solvent bath
    - Dry Ice with Acetone
      - As low as -78˚C (-109˚F)

Hazards – Solvent Based Extraction Equipment

- Purge Gases (Displace Oxygen)
  - Argon
  - Nitrogen
  - Helium

Hazards – Solvent Based Extraction Equipment

- Ethanol
  - AKA: Ethyl Alcohol; Grain Alcohol
  - Typically not pressurized may be in vacuum
  - -100°F to 212°F
  - Up to 100 gallons

Hazards – Solvent Based Extraction Equipment

- Ethanol
  - External Pressure (Vacuum) or atmospheric
  - Pressure (must ensure pressure relief)
  - Explosion/Fire
  - Contact with Eyes/Skin

Hazards – Other Chemicals

- Other chemicals that may be present
  - Isopropanol
  - Acetone
  - Heptane
  - Hexane
  - Pentane

UNDERSTANDING THE EXTRACTION PROCESS

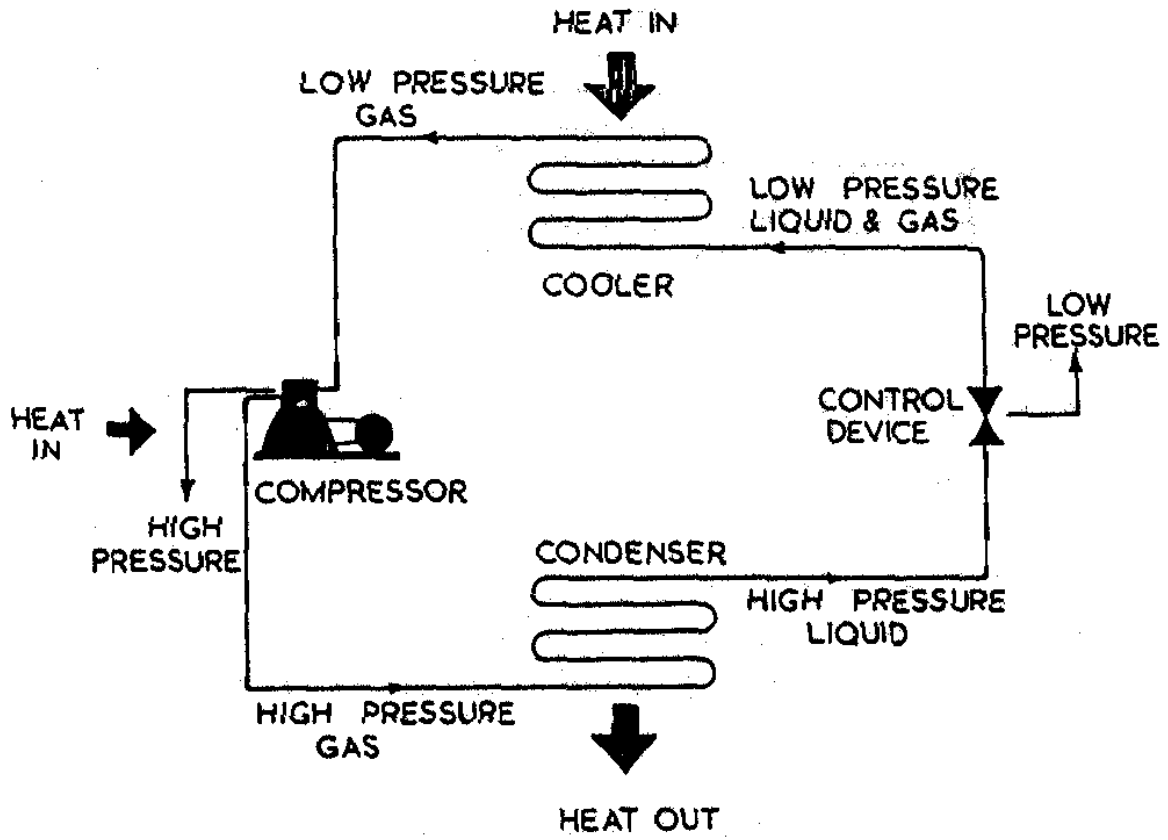
What is this Process and Which Codes Apply?

- Before we get to which codes are relevant, we must understand what the process is.
  - Industrial Process or Refrigeration Cycle?
  - Is NFPA 36 Standard for Solvent Extraction Plants relevant?

A Refrigeration Cycle this is NOT

- Butane and Propane may be used as a refrigerant in some applications (more prevalent outside of US)
- This process is NOT a refrigeration cycle
- This process may be achieved without a compressor (thermal cycle only)
- Represented to AHJs as a refrigeration cycle (false)
  - Only needs to comply with IMC Chapter 11 (false)
  - Containers are routinely opened
  - Refrigeration Cycles do not include plant material

A Refrigeration Cycle this is NOT

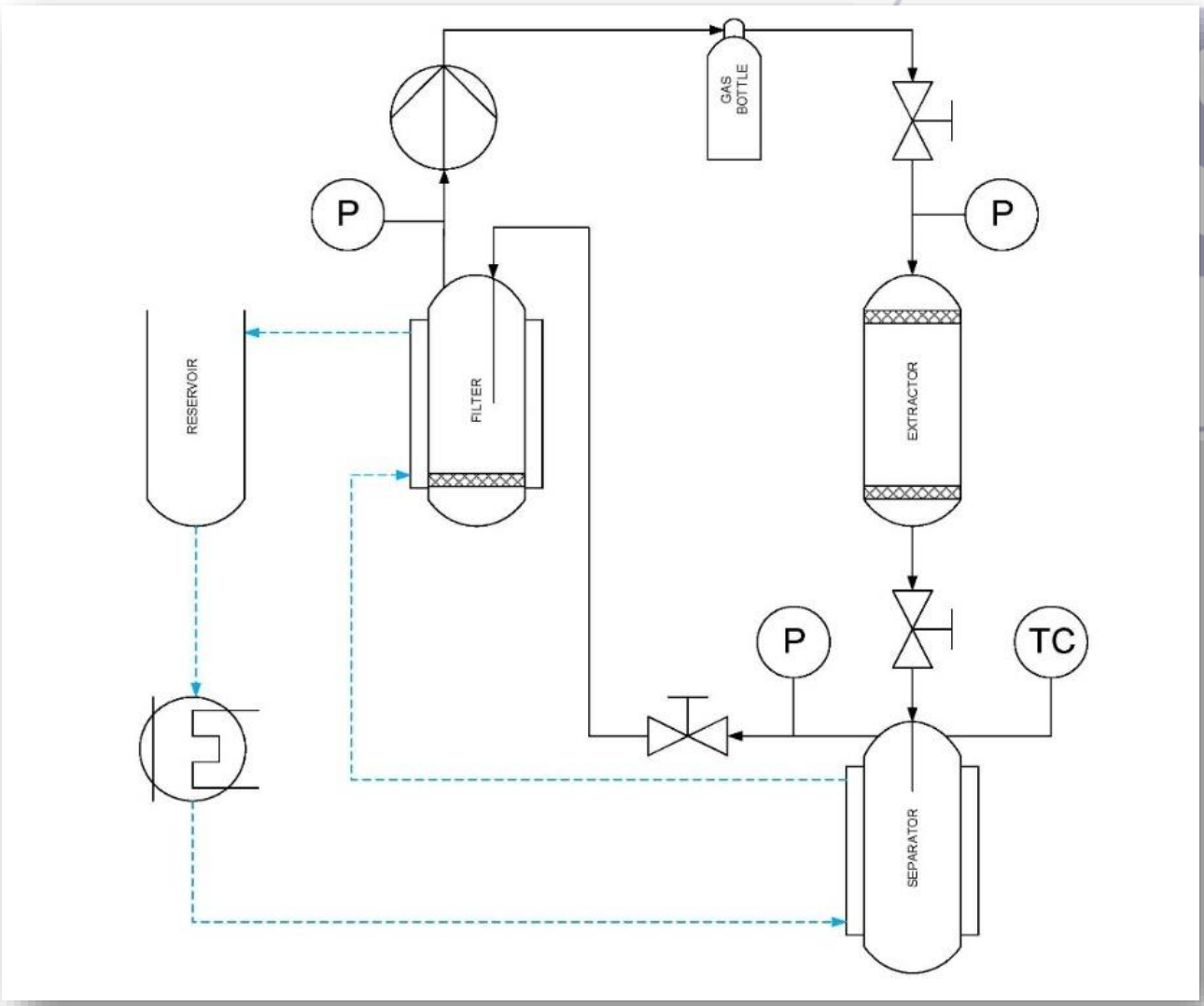


BASIC REFRIGERATION CYCLE

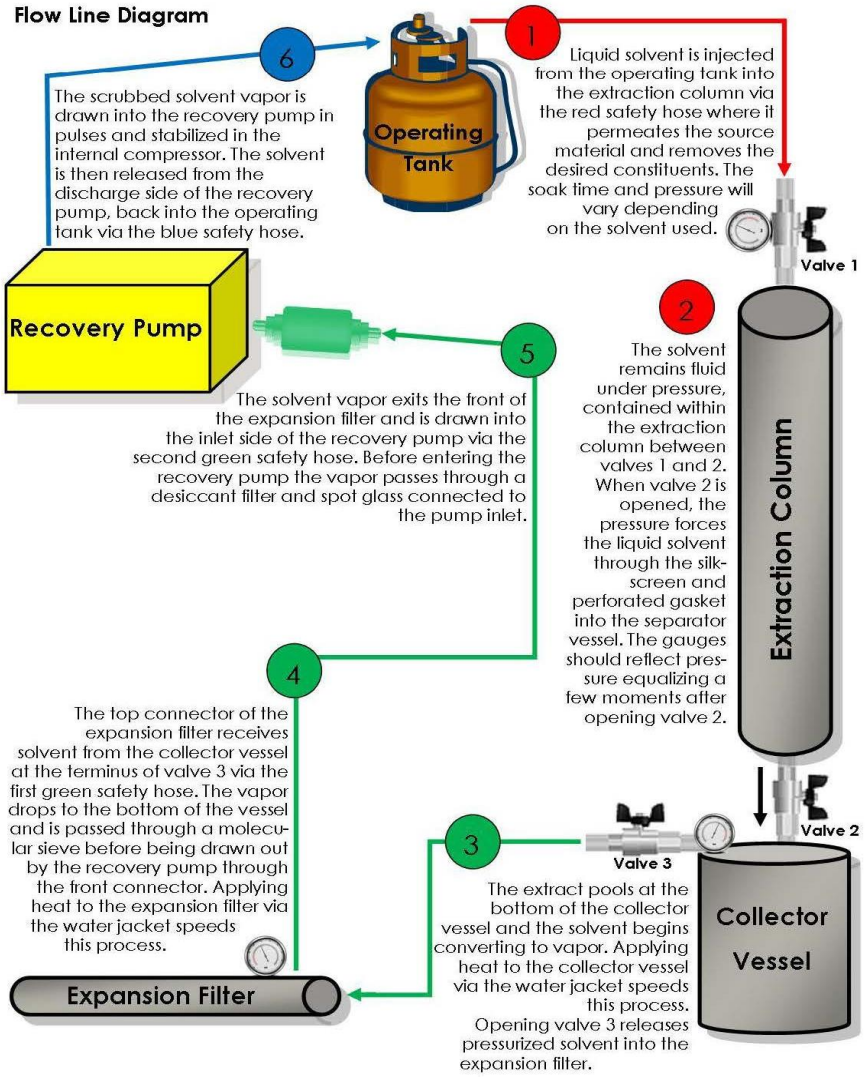
Industrial Process

- This is an industrial chemical process
- The solvent is condensed and evaporated in order to introduce or remove the solvent from the product, not to provide cooling

Industrial Process



Industrial Process



EXTRACTION EQUIPMENT HISTORY

A brief History of Extraction Equipment

- From illegal operations to legal – it's a struggle
  - No regulation
  - No procedures
  - No training
- Evolved from a PVC pipe in a backyard…

A brief History of Extraction Equipment

A brief History of Extraction Equipment

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A brief History of Extraction Equipment

CODES AND STANDARDS

NFPA 36

- Standard for Solvent Extraction Plants
  - Chapter 1 Scope:
    - 1.1.1 This standard shall apply to the commercial scale extraction processing of animal and vegetable oils and fats by the use of **Class I flammable hydrocarbon liquids**, hereinafter referred to as “solvents.”
    - 1.1.9 This standard **shall not apply** to extraction processes that use flammable gases, **liquefied petroleum gases**, or **nonflammable gases**.

NFPA 36

- Scale or the processing plant:
  - Intent is for a large facility
  - Thousands of gallons of solvent
  - Outdoor processing
  - Conveyor systems
  - Cooling towers
  - Massive throughput – think about how much coffee needs to be decaffeinated…
  - Does not take into account security concerns specific to this industry

Solvent Extraction Plant - Example

Solvent Extraction Plant - Example

Solvent Extraction Plant - Example

NFPA 36

- Does NOT apply to small scale cannabis processing

Think of this industry as a small craft brewery compared to the Coors brewery

Codes & Standards

- International Fire Code (IFC)
- NFPA
  - NFPA 1 (Fire Code) Chapter 38 (new chapter in development)
    - Will not include details on equipment requirements (very focused on facility requirements)
  - NFPA 58 (Liquefied Petroleum Gas Code)
    - This type of process equipment is not included in scope
  - NFPA 55 (Compressed Gases and Cryogenic Fluids Code)
    - This type of process equipment is not included in scope
  - NFPA 45 (Standard on Fire Protection for Laboratories Using Chemicals)
    - Manufacturing plants not included in scope
  - NFPA 30 (Flammable and Combustible Liquids Code)
  - ASME Boiler and Pressure Vessel Code

NFPA 58

- Liquefied Petroleum Gas Code
  - Code is aimed at storage and use of LPG as a fuel
  - Only code that specifically deals with LPG
  - Scope
    - (1) Containers, piping, and associated equipment, when delivering LP-Gas to a building for use as a fuel gas.
    - (2) Highway transportation of LP-Gas.

NFPA 58

- Liquefied Petroleum Gas Code
  - Non-application of Code
    - (4)* Chemical plants where specific approval of construction and installation plans is obtained from the authority having jurisdiction
    - A.1.3.2(4) The exclusion of the use of LP-Gas as a chemical reactant (feedstock) or in processes recognizes the unique and complex fire hazard problems that often exist in a chemical plant. The term chemical plant includes all facilities owned by chemical companies where **LP-Gas is used primarily as a chemical reactant, process solvent gas, or solvent.** However, there is no standard definition of a chemical plant, and facilities in which few or no chemical reactions are carried out may be called chemical plants.

NFPA 58

- Relevant Parts of NFPA 58
  - Parts of Chapter 5: LP-Gas Equipment and Appliances
    - Materials of Construction (Chemical Compatibility)
    - DOT and ASME requirements
      - Maximum Allowable Working Pressure of ASME containers
    - Pressure Relief Requirements
    - Warning Labels
    - Hose requirements
    - Safeguards for 100% liquid LPG (no vapor space) trapped in a piping system (Hydrostatic Pressure)

NFPA 55

- Compressed Gases and Cryogenic Fluids Code
  - Code is aimed at storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary cylinders, containers, equipment, and tanks in all occupancies.

NFPA 55

- Compressed Gases and Cryogenic Fluids Code
  - Non-application of Code
    - (6) Storage, use, and handling of liquefied and nonliquefied compressed gases in laboratory work areas in accordance with NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals

NFPA 55

- Relevant Parts of NFPA 55
  - Parts of Chapter 13: Insulated Liquid Carbon Dioxide Systems
    - Pressure Relief
    - Vent Pipe Systems (PRV exhaust)
    - Burst pressures ** (already covered by ASME for pressure vessels)

NFPA 45

- Fire Protection for Laboratories Using Chemicals
  - Code is aimed laboratory environments
  - Scope
    - 1.1.1 This standard shall apply to laboratory buildings, laboratory units, and laboratory work areas whether located above or below grade in which chemicals, as defined, are handled or stored.

NFPA 45

- Fire Protection for Laboratories Using Chemicals
  - Non-application of Code
    - (4) Laboratories that are primarily manufacturing plants

NFPA 45

- Relevant Parts of NFPA 45
  - In general this is process uses laboratory equipment and is very similar to a laboratory environment.
    - Refrigerator/Freezer requirements
    - Chemical Fume Hood requirements

NFPA 30

- Flammable and Combustible Liquids Code
- Code
  - Scope
    - 1.1.1* This code shall apply to the storage, handling, and use of flammable and combustible liquids, including waste liquids, as herein defined and classified.

NFPA 30

- Flammable and Combustible Liquids Code
  - Ethanol processing does fall into the scope of this document
  - This code does not cover chemical fume hoods
  - This code does not cover freezers/refrigerators

ASME Boiler and Pressure Vessel Code

- Section VIII Division 1
  - Rules for the Construction of Pressure Vessels
  - Scope
    - (2) For the scope of this Division, **pressure vessels are containers for the containment of pressure**, either internal or external.
    - (3) This Division contains mandatory requirements, specific prohibitions, and nonmandatory guidance for **pressure vessel materials, design, fabrication, examination, inspection, testing, certification, and pressure relief.**

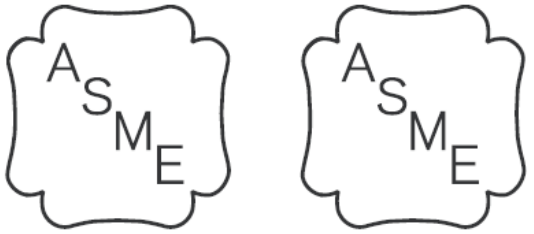
ASME Boiler and Pressure Vessel Code

- When is ASME BPVC applicable?
  - Compressed gas containers, cylinders and tanks shall be designed, fabricated, tested, marked with the specifications of manufacture and maintained in accordance with the regulations of the ASME Boiler and Pressure Vessel Code, Section VIII (IFC 5303.2).
  - Non-application of code
    - (-1) vessels having an **internal or external pressure not exceeding 15 psi** (100 kPa)
    - (-i) vessels having an inside diameter, width, height, or cross section diagonal **not exceeding 6 in.** (152 mm), with no limitation on length of vessel or pressure
- Therefore all vessels containing pressure in excess of 15 psi with an internal diameter greater than 6” falls into the scope

ASME Boiler and Pressure Vessel Code

- UG-116 Required Markings
  - Official Certification Mark
  - Name of the manufacturer
  - MAWP
  - MDMT
  - Manufacturer's serial number
  - Year built

Figure UG-116
Official Certification Mark to Denote the American Society of Mechanical Engineers' Standard

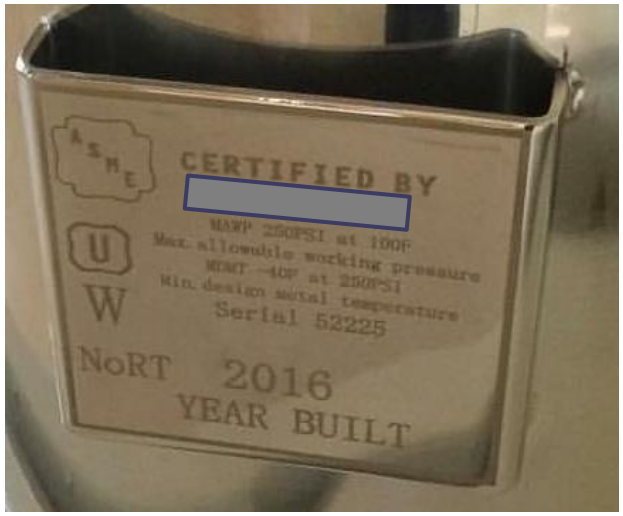


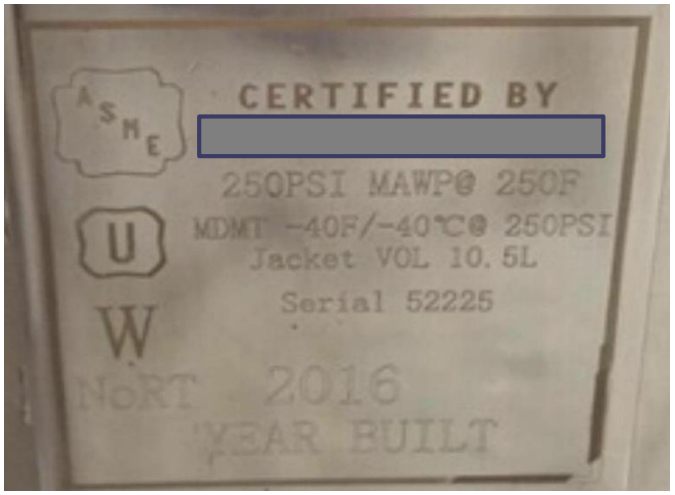
U (a) UM (b)

- Most States require registration with National Board

ASME Boiler and Pressure Vessel Code

Counterfeit ASME Nameplates – Imported from China





Equipment Code Path

- International Fire Code invokes:
  - NFPA 55 (CO_2 systems)
  - NFPA 58 (LPG systems)
    - ASME BPVC
  - ASME BPVC

STATE RULES

State Specific Rules

- Some States have developed rule for the processing of marijuana
  - Typically written by attorneys or politicians with no technical knowledge
  - Add requirements above and beyond adopted codes and standards
  - Processors must comply with state rules and local rules

State Specific Rules

- What about hemp?
  - Uses the same equipment!
  - Usually not required to follow the same State rules!

California

- AB-2679
  - Equipment must:
    - Be closed loop
    - (iii) A licensed engineer certifies that the system was commercially manufactured, safe for its intended use, and built to codes of recognized and generally accepted good engineering practices, including, but not limited to, the American Society of Mechanical Engineers (ASME), the American National Standards Institute (ANSI), Underwriters Laboratories (UL), the American Society for Testing and Materials (ASTM), or OSHA Nationally Recognized Testing Laboratories (NRTLs).

Other State Rules

- Existing State rules for equipment and facility design may be misleading
- As new States develop rules they tend to use other State rules as a template
- Errors are repeated

International Fire Code

“equipment shall be listed or approved”

LISTINGS

NRTL (Nationally Recognized Testing Lab)

- UL, ETL, etc. (OSHA approved)
- Cons
  - No procedure for this type of equipment
  - Not Code based (no procedure)
  - No pressure vessel analysis
  - No Process Hazard Analysis
  - No chemical compatibility test
  - No field verification
- Pros
  - Addresses electrical systems (will not list equipment as a whole)

ETL Listing of a LPG Extractor

- Issued in 2012
- UL Standard for Safety Motor-Operated Appliances (ANSI/UL 73)
- Tests Performed:
  - Stability Test
  - Leakage Current Test
  - Starting Current Test
  - Input Test
  - Dielectric Voltage Withstand Test
  - Operation Test
- Listing was not renewed by Intertek in 2013

ETL Listed Extractor

4.0 Critical Components

Photo #	Item no.[1]	Name	Manufacturer/ trademark[2]	Type / model[2]	Technical data and securement means	Mark(s) of conformity[3]
1	1	Accessory	[redacted]	Various	Stainless Steel	NR
1	2	Recovery Pump	Various	Various	115V, 60Hz, 7.1A, 1/2HP	cULus

NOTES:

1) Not all item numbers are indicated (called out) in the photos, as their location is obvious.

2) "Various" means any type, from any manufacturer that complies with the "Technical data and securement means" and meets the "Mark(s) of conformity" can be used.

3) Indicates specific marks to be verified, which assures the agreed level of surveillance for the component. "NR" - indicates Unlisted and only visual examination is necessary. "See 5.0" indicates Unlisted components or assemblies to be evaluated periodically refer to section 5.0 for details.

ENGINEERING PEER REVIEWS

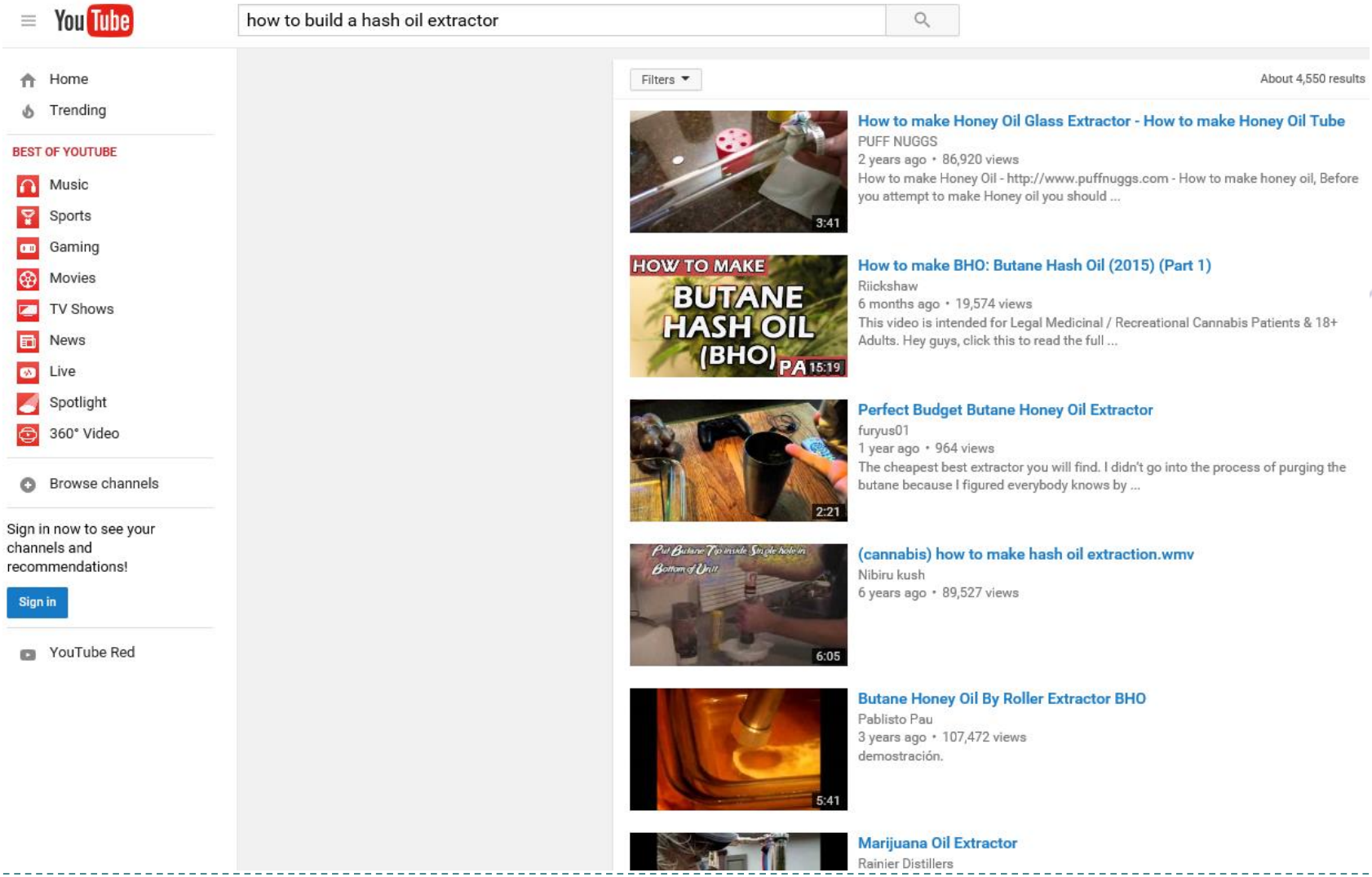
Peer Reviewed Equipment

- Value of a Peer Review
  - Code Based Review
  - Pressure Safety Evaluation
    - Pressure Vessel Analysis
    - Pressure Relief Evaluation
  - Chemical Compatibility of Materials
  - Process Hazard Analysis
  - Operation & Maintenance Manual Review
    - Equipment Safety
    - Minimum Facility Requirements
- Allows for Meaningful Field Verification

Why are Peer Reviews a good idea?

- Codes and Standards
  - No specific standard for this equipment, though portions of existing codes are relevant
- Ensures system is “Closed Loop”
  - “Open Blasting” is illegal and dangerous
- A lot of equipment in this industry is not “engineered or designed” by qualified individuals
- No (or Few) Quality Assurance Programs
- YouTube

YouTube

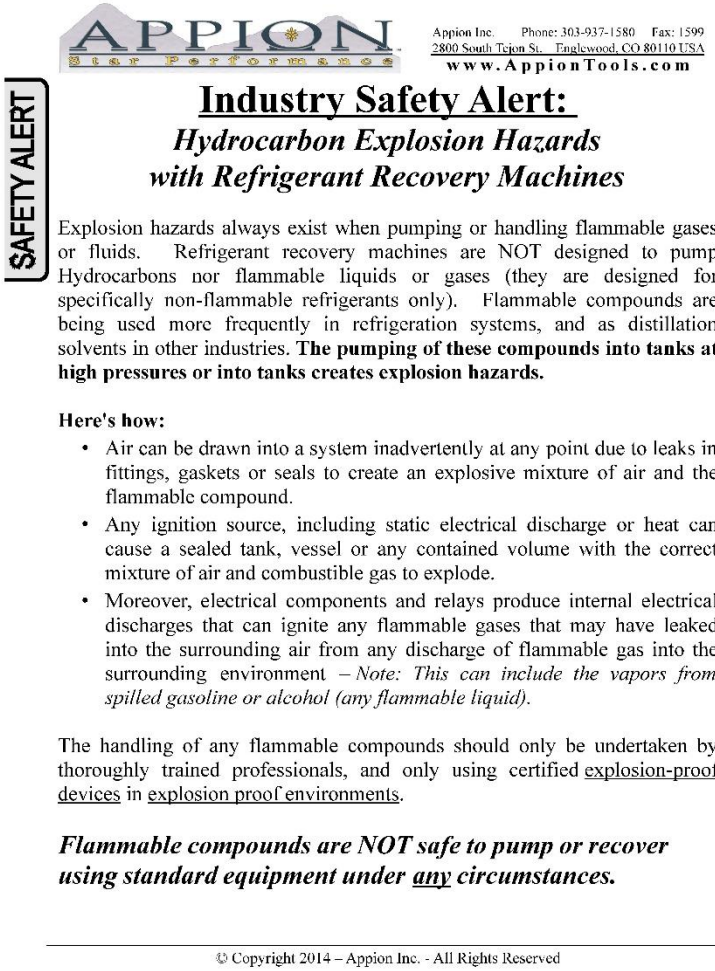


Sample BHO Extractor

What's wrong with that extractor?

- Glass Material Column
  - Is likely fine for normal operation (low pressure)
  - Is NOT ok in an abnormal situation
  - Not per code
- No apparent Pressure Relief
- Pressure Gauges only read to 60 psig
- Vessels over 6" Diameter need to be ASME or DOT vessels
- Recovery Pump is not rated for use with Hydrocarbons (only to be used with non-flammable refrigerants)

Appion Industry Bulletin



APPION
Blue Performance

Appion Inc. Phone: 303-937-1580 Fax: 1599
2800 South Tejon St. Englewood, CO 80110 USA
www.AppionTools.com

SAFETY ALERT

Industry Safety Alert:

Hydrocarbon Explosion Hazards with Refrigerant Recovery Machines

Explosion hazards always exist when pumping or handling flammable gases or fluids. Refrigerant recovery machines are NOT designed to pump Hydrocarbons nor flammable liquids or gases (they are designed for specifically non-flammable refrigerants only). Flammable compounds are being used more frequently in refrigeration systems, and as distillation solvents in other industries. **The pumping of these compounds into tanks at high pressures or into tanks creates explosion hazards.**

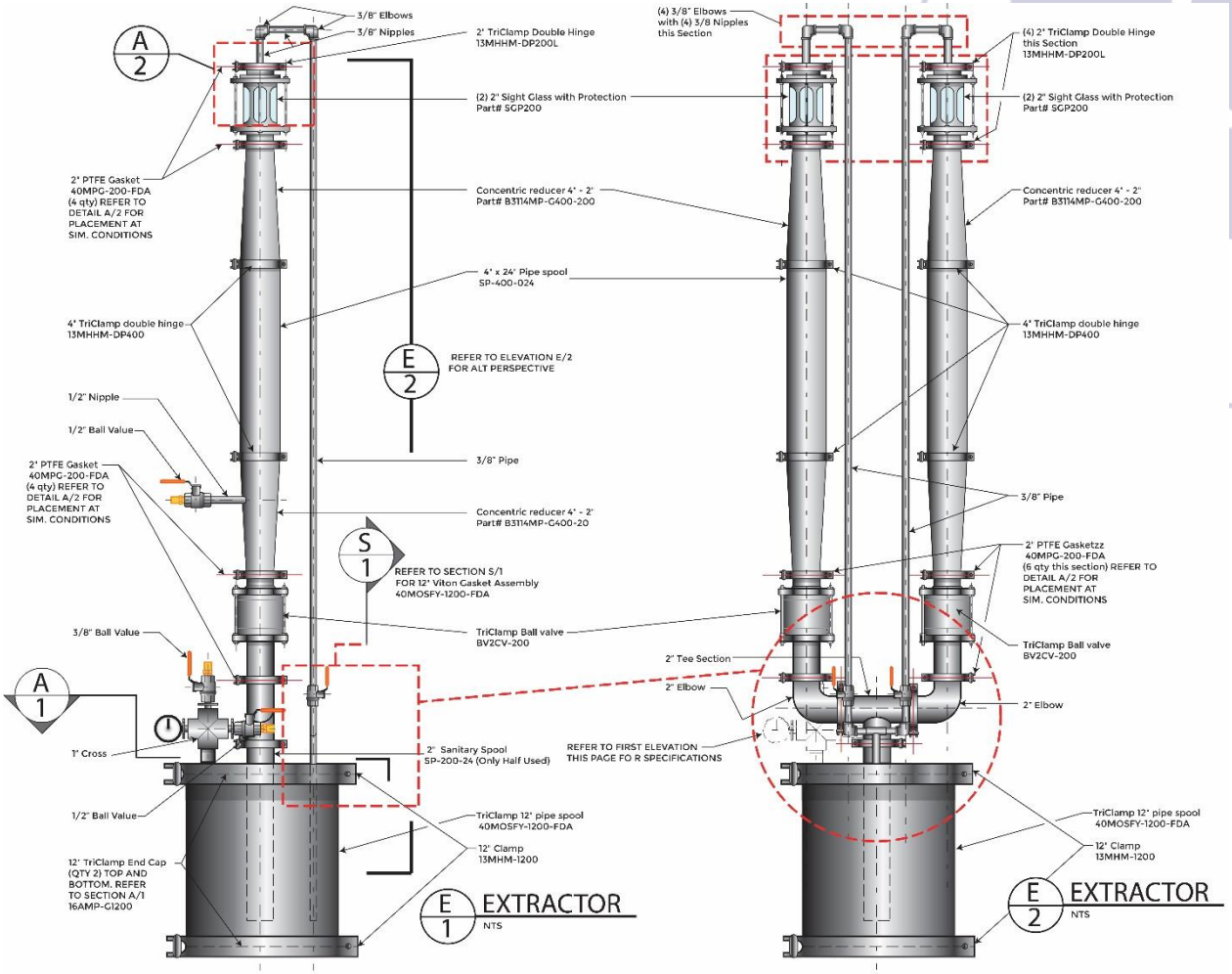
Here's how:

- Air can be drawn into a system inadvertently at any point due to leaks in fittings, gaskets or seals to create an explosive mixture of air and the flammable compound.
- Any ignition source, including static electrical discharge or heat can cause a sealed tank, vessel or any contained volume with the correct mixture of air and combustible gas to explode.
- Moreover, electrical components and relays produce internal electrical discharges that can ignite any flammable gases that may have leaked into the surrounding air from any discharge of flammable gas into the surrounding environment – *Note: This can include the vapors from spilled gasoline or alcohol (any flammable liquid).*

The handling of any flammable compounds should only be undertaken by thoroughly trained professionals, and only using certified explosion-proof devices in explosion proof environments.

Flammable compounds are NOT safe to pump or recover using standard equipment under any circumstances.

Sample Extractor Design



What's wrong with that extractor?

- No Support Frame
- Attached to a 200 pound Propane Tank
- Attached to a pump that can produce 1450 psig of output pressure
- Collection Tank is NOT ASME or DOT
- No pressure relief
- Equipment is not capable of pressures in excess of 90 psig

Bottom Line

- ISIS would be proud! This company successfully engineered a bomb!
- All parts purchased from a brewery supply store and assembled in a garage.
- Company is no longer in business

Peer Review Process

- PSI analyzes the original configuration of the equipment
- Analysis identifies shortcomings of equipment which is then submitted to the OEM for resolution
- OEM must resolve open safety issues by replacing components, adding components, or redesigning part of the equipment
- OEM then submits updated design to PSI for analysis
- If all items are resolved, PSI issues report stating that the equipment is satisfactory

INSPECTIONS

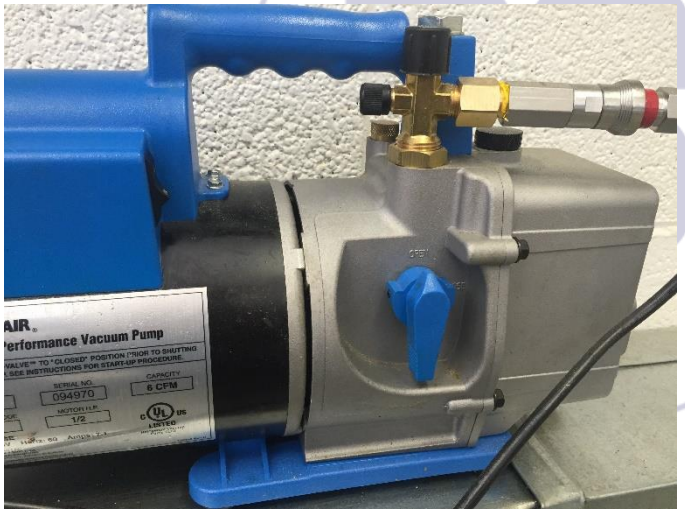
EPRs, Inspections & Field Verifications

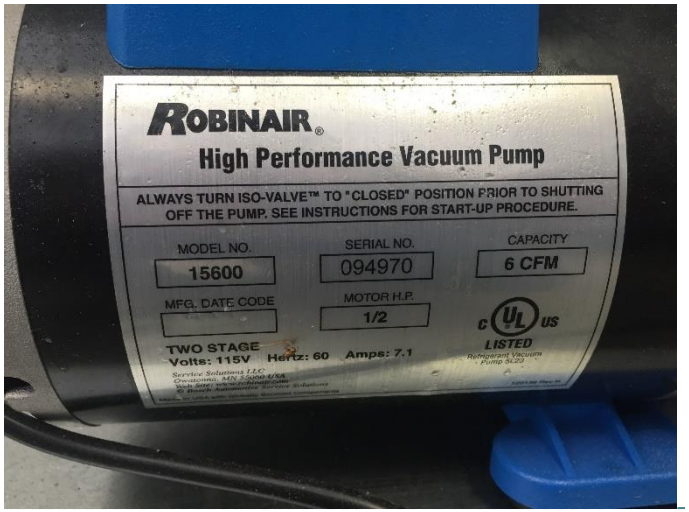
- Performed EPRs for over 50 OEMs
  - http://www.psinspectors.com/peer-reviews.html
- Hundreds of facilities across California, Colorado, Nevada, Oregon, & Washington
- Includes facility and equipment inspections
- 100% of the facilities FAIL the first inspection
  - SOP Issues
  - Facility Issues
  - Equipment Issues
  - Training Issues

Installation Issues

- Facility, Equipment Installation, and Procedural issues are rampant!

The Ugly





The Ugly

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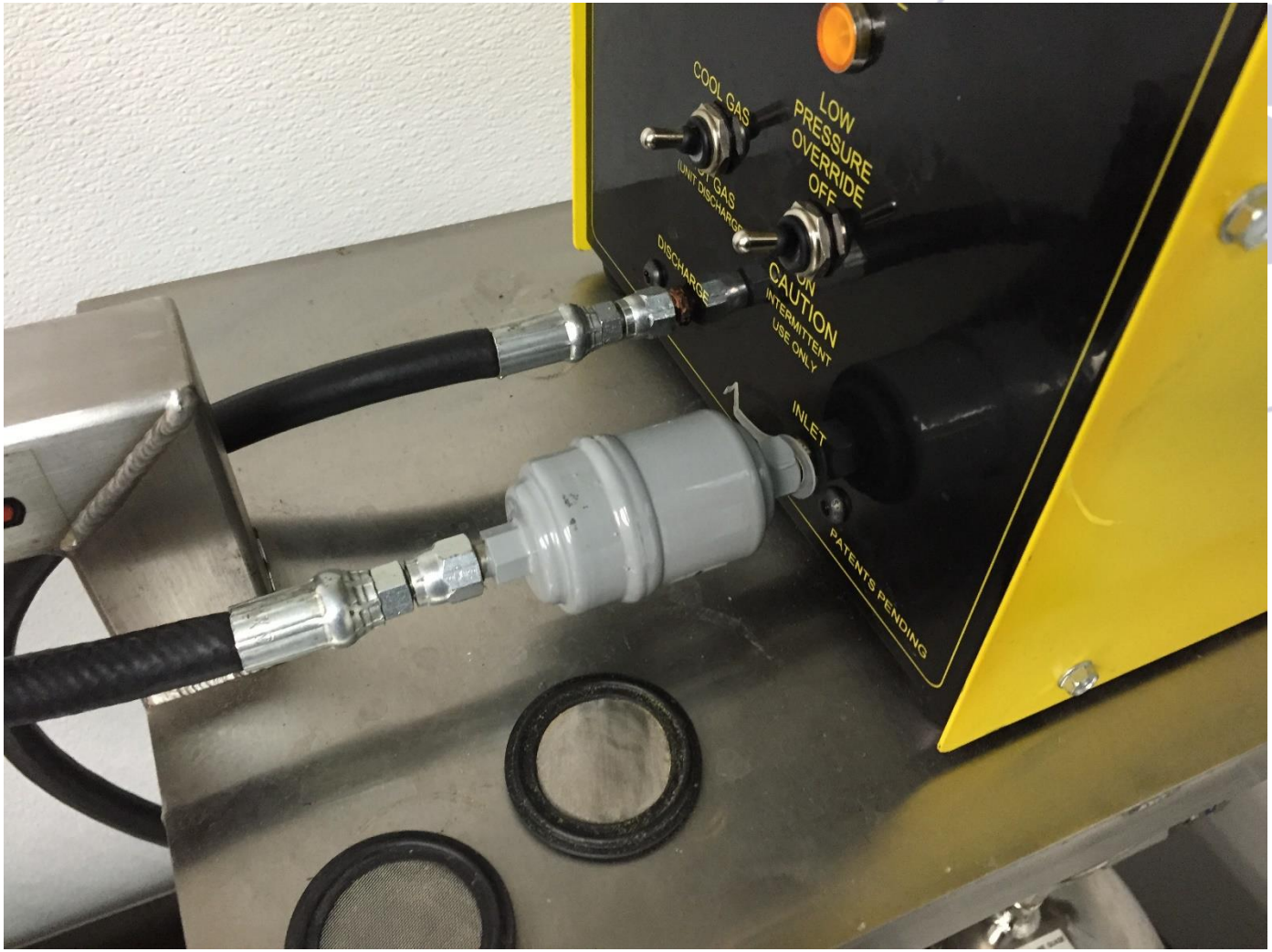


The Ugly

The Ugly

Equipment Verification

- Colorado was the first state to require an engineering peer review or a NRTL listing of extraction equipment
- Most extraction equipment manufacturers have had to modify their design because of Colorado extraction rules
- Older models likely include non-compliant parts
- Extraction Equipment is not always purchased from the manufacturer (Craigslist is a common resale vehicle)
- Users like to customize equipment or modify with cheaper components

FIELD VERIFICATION

What is a Field Verification?

- A Field Verification ensures that the equipment is installed in accordance with the engineering peer review
- Modeled after a NRTL field verification

Why is this needed?

- No codes/standards for this equipment
- No Listing for this equipment
- Not regulated by the Federal government
- A lot of the equipment manufacturers are start ups
- No Quality Assurance programs
- Some equipment manufacturers do not have the proper engineering knowledge
- Historically only ~40% of the equipment passes the first time.
- Manufacturer may still sell non-certified equipment**

What is a Field Verification?

- Items reviewed during a field verification:
  - P&ID (Piping and Instrumentation Diagram) or PFD (Process Flow Diagram
  - All Vendor Components are checked (i.e. Valves, PRVs, Gauges, Pumps, etc.)
  - Fabricated Components are verified
  - Warning Labels are reviewed for operating conditions
  - Equipment Nameplate including model and serial number are cataloged
  - Inspection is documented with photographs

What is a Field Verification?

- Additional Benefits
  - A process discussion is conducted with the end user
  - Periodic Maintenance
  - Torqueing
  - Importance of SOPs
  - Hydrocarbon/CO_2 alarms (placement; emergency procedure; etc.)
  - Exhaust system may be discussed
  - Relief Venting
  - Technical discussions (i.e.: Rupture Disks vs Proportional Relief Valves; Cryogenic temperatures; Elastomers; etc.)

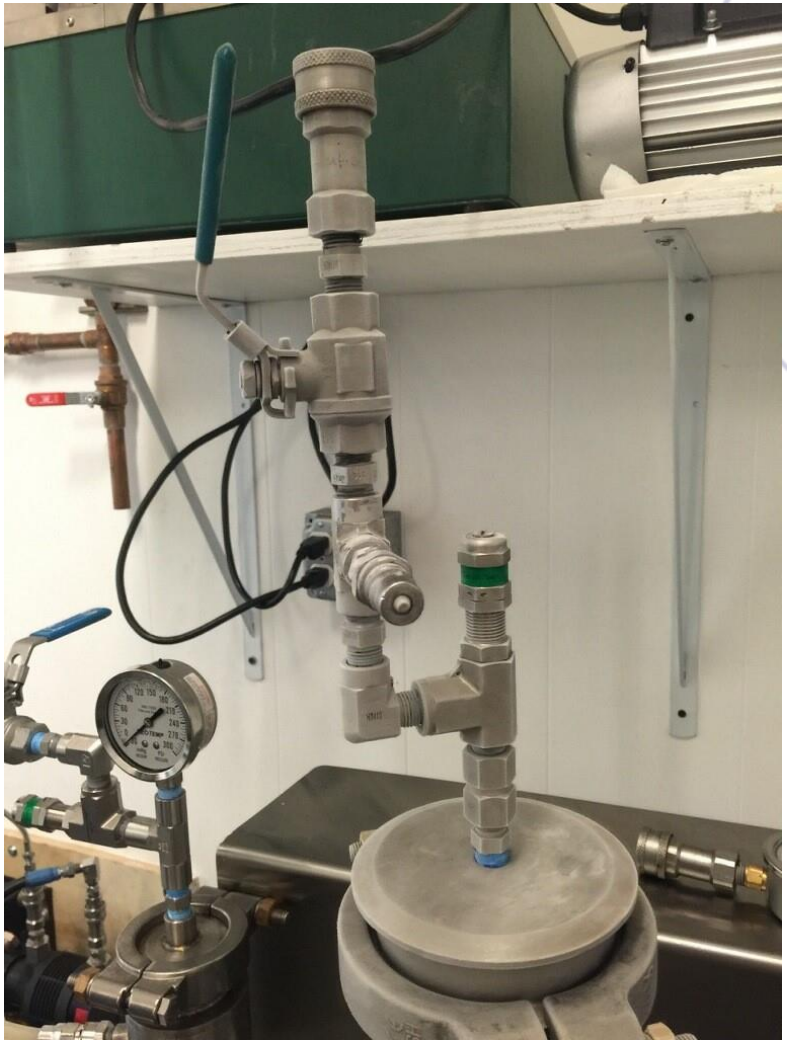
Issues with Used Equipment

- Pressure Ratings of Components
- No Pressure Relief
- Chemically incompatible materials (EPDM, silicone)
- Incorrect Assembly
- Hoses not per code
- Customization

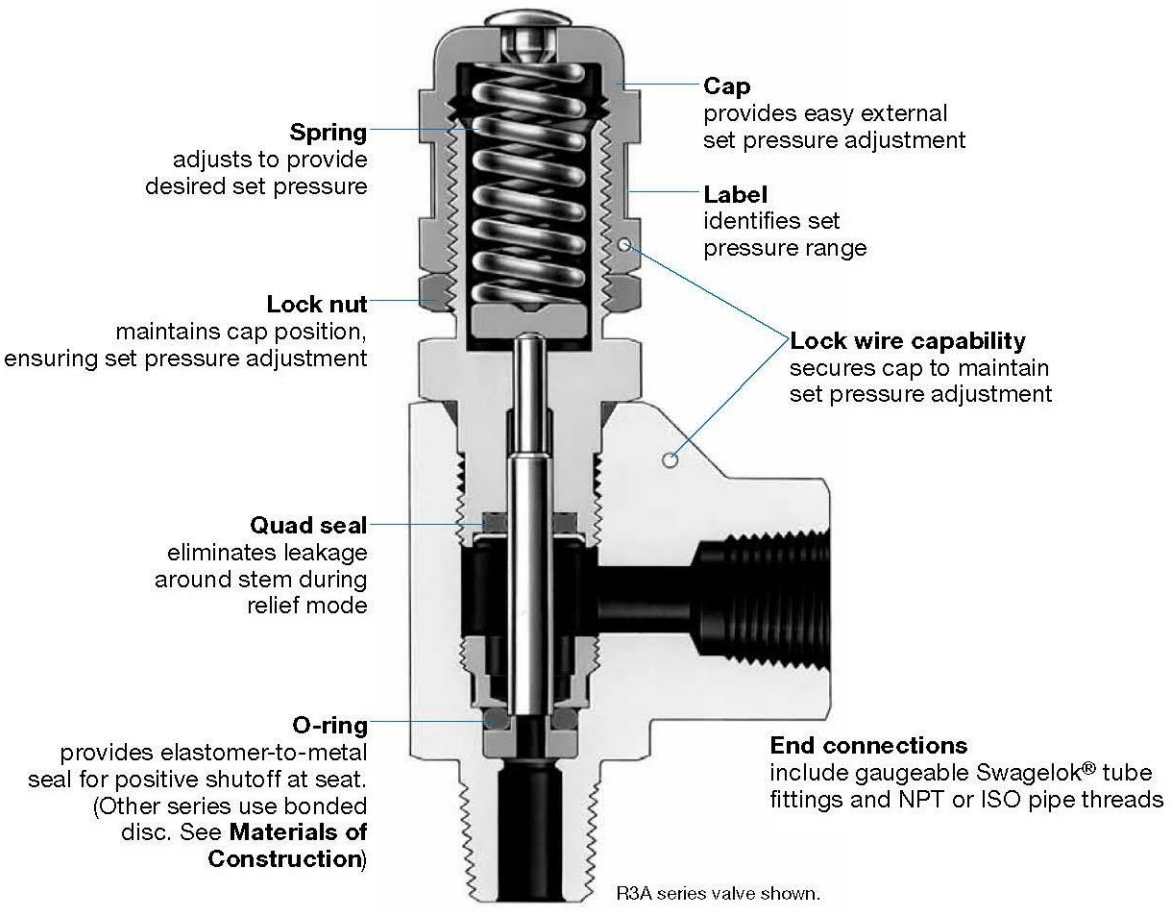
Improper CO_2 Venting

Improper Placement of Equipment

Bypassing Safety Features



Pressure Relief Valve Detail



Bypassing Safety Features

Subzero Temperatures

- New trend is to super cool the product to separate plant oils to further refine the product
- Most equipment is designed for use from -20°F to 125°F
- Some end users assume they can use dry ice solutions to supercool to temperatures of -100°F
- Equipment must be specially designed for use at these temperatures
- Leads to:
  - Elastomer Failures
  - Valve Failures
  - Clamp Failures

Subzero Temperatures

Improper Assembly

Improper Assembly

Operating Procedures

- Some procedural issues can be determined during a field inspection
- SOPs should be reviewed by a third party professional

SOP Review

- Ensures that:
  - Operator is not deviating from the OEM instructions
  - All safety checks are addressed
  - Waste Disposal is addressed
  - Appropriate detail is included in the SOPs
  - Emergency situations are addressed
  - Periodic Maintenance is addressed

Facility in Denver, CO

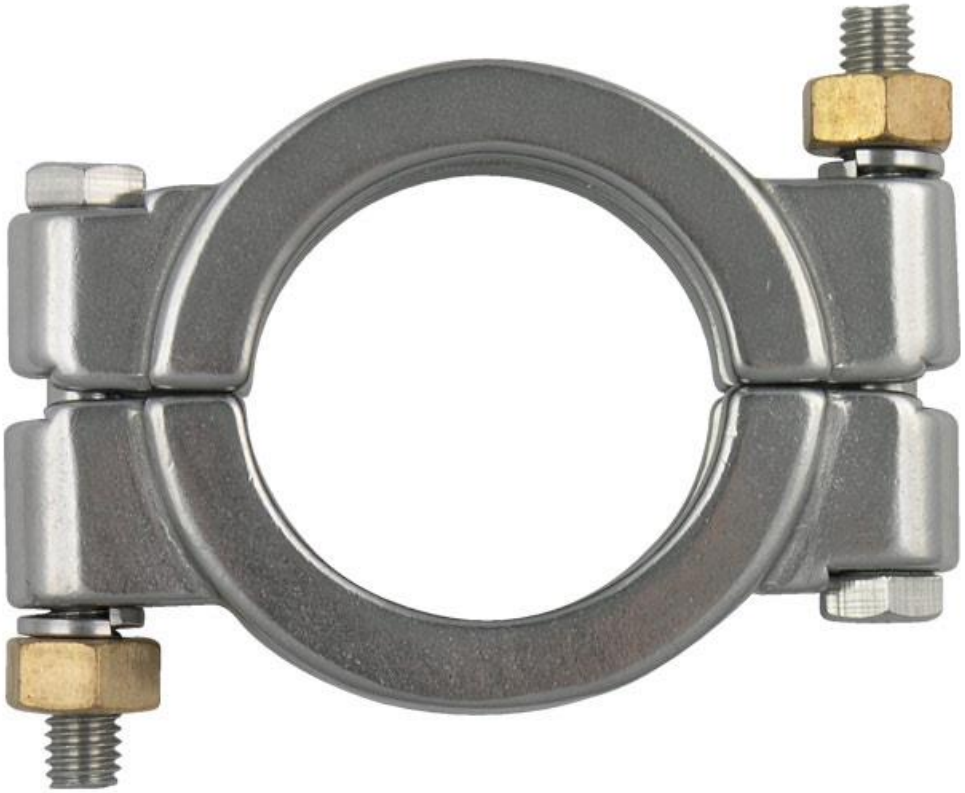
Accident in Denver, CO

- Clamp Nuts were stripped due to overtightening
- Clamp Bolts/Nuts had not been replaced since original purchase
- Extractor lid blew off at 30 psig (12” Diameter lid)
- Hazardous exhaust system not sufficient
- No ignition (whew!)
- SOPs had not been properly reviewed
- Equipment had not been field verified
- OEM did not list torqueing specs in manual
- Operator had not received proper training and didn’t know what a Torque wrench was
- Force of Lid at launch was between 2800 and 3400 LBS

Torqueing Procedures

- All pressure closures are required to be torqued to a specific value in order to properly seal the system
- Includes:
  - Sanitary Clamps
  - Flanges
- Ensures the bolts/nuts are not overtightened (stripped)

Sanitary Clamps



Sanitary Clamp Connection

Is it possible to use LPG Safety?

- Yes, of course.
- What's required:
  - Proper Equipment
  - Proper Operating Procedures
  - Proper Facility Safety
  - Proper Training

Q&A

Questions?