State of the Art in Equipment for Polyurethane Formulation and Injection using:

PENTANE, METHYLAL, METHYL FORMATE, HFOs, WATER

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Pentane

- Safety concepts processing Pentane
- Pentane and process: safe conversion concepts
- Major changes on foaming machines
Safety concepts processing C-Pentane

Explosion Limits & Explosive sensors settings

8.0 % Volume 8 gr. each 100 lt. of air

1.4 % Volume 1.4 gr. each 100 lt. of air

Attention!

Explosion

Max concentration

Min. Concentration = 100 % Sensors Set

Danger Safety

Note: Exhaust Ventilation and Sensors are always switched on
Pentane emission

- Several studies have been conducted to measure Pentane emission during foaming.

- Pentane is emitted up to a concentration of 2% of overall Pentane contained into the formulation.

- Nearly all Pentane gas is lost in the last quarter of foaming with much higher concentrations in the areas near the venting holes.
Key concept

“To take measures to prevent the creation of explosive Pentane - air mixture”

- Explosive gas sensors
- To ensure minimum 10 air changes per hour in the dangerous areas
- Monitor ventilation efficiency
- Nitrogen pressurization into the tanks
- Properly grounding of all metallic parts
- To consider the blend Polyol/Pentane as pure Pentane
- Cavity inertisation by Nitrogen before foaming
Plant Alarm Control Panel

Control of all the alarms of:
- Storage
- Premix unit
- Foaming machines
- Foaming areas
Pentane and process: safe conversion concepts

Process critical areas

- Storage
- Pure Pentane distribution pipeline
- Premix unit
- Blended polyol distribution pipeline
- Foaming machine line
- Foaming area
Pure Pentane Storage

- Storage Tank/s could be above or underground (high consumption)
- Storage by 200 Lt Drums (low consumption)
- Dual wall tank/s for leakages monitoring
- Process under inert gas (Nitrogen)
- All metal parts grounded
- Explosive gas sensors
- Pentane vapours recovered into the truck during tank filling
Pure Pentane Storage over ground
Pure Pentane Storage under ground
Pure Pentane Storage under ground
Pure Pentane Storage by Drums
**Pure Pentane Distribution**

- Single pipeline, welded (not flanged) from storage to premix unit/s (if external to buildings) dual wall pipeline when internal to buildings
- Automatic shut off of fire safe valve and electrical power in case of leakages
- Pumps for explosive liquids with Ex. proof motors
Pure Pentane Distribution
Premix Unit

Premix Unit for perfectly mixing Polyol with Pentane, included in a suction box with:

- Static mixer with pentane pump
- Daily Tank with specs. for pentane
- Fire safe valve connected to sensors, to stop mixing in case of leakages
- Gas sensors near the roof and near the floor
- Pump with Ex_i motor for foaming machine refilling
Premix Unit
Pure Pentane Dosing Line
Static Mixer Column for Polyol-Pentane Blending
Blended polyol tank
Blended polyol tank requirements:

- Relief and Safety Valves, suitable for Nitrogen pressurization of flammables-liquids
- Magnetic-drive for pressure up to 10 bar
- Max. Pressure Valve (9 bar) discharging to outside, above the roof
- Explosion proof Capacitance Levels with working/minimum/maximum set points
- Explosion proof Capacitance maximum safety level (SuperMax)
**Blended polyol distribution pipeline**

- Single, external, pipeline from Daily tank to workshop
- Dual wall pipeline with on/off valves inside workshop
- Leakages monitoring
- Pumps for explosive liquids with Ex. proof motors
Foaming Machine
Foaming Machine Polyol - Pentane Line
Foaming Area

- Foaming Area enclosed in a suction cabin
- Localised ventilation on foaming points

WITH

- Gas sensors
- A minimum of 10 air changes per hour in the dangerous area and inertisation of the cavities
- Electrical power cut off for the first 90” after foaming where necessary
Foaming Areas
Localised Ventilation for Continuous Panels Production Line
Pentane Sensor
Cavities inertisation with $N_2$

2 times the volume is requested to reach $O_2$ target concentration ($<11\%$) in order to minimise the flammability of the air/pentane vapours.
NITROGEN GENERATOR
Suction Group for the Suction Cabins and Localised Ventilations

The suction group requires:

- Explosion-proof motor
- Differential pressure switch, to continuously monitor the suction efficiency
- Sparkle-free fan
- Gas sensor in the suction mainfold
Major changes on foaming machines

Three possibilities

- New machine built for Pentane
- New “half machine” built for Pentane
- “Retrofitting” of existing foaming machine
New Machine built for Pentane
Foaming Machine for Pentane
(Continuous Panel Production Line)
New “Half Machine” built for Pentane
In any case in the Polyol side of the machine there will be a suction cabin including:
- Polyol tank with specs. for Pentane
- Explosive gas sensors
- Drip-pan with “catch” basin (capacity= tank capacity) with floating sensor
- Polyol pump with EX_i motor

No modification on Isocyanate line are requested
“Retrofitting” of an existing foaming machine

- Pressure gauge for nitrogen pressurization on polyol tank
- Super max levels to be installed on polyol tank
- Supply of all the intrinsically-safe barriers to the electrical apparatus related to the polyol-pentane metering line
- Fail-safe valves for the polyol-pentane feeding/return line
- Modification of the electric control panel, in order to remove it 2-3 m out of the machine
- Liquid sensor in drip-pan
- Drip pan under polyol tank
- Suction cabin complete of 1 group of electro-ventilator & air flow-meter
- Centralized alarm control panel for handling and control of the high pressure metering machine and all the foaming areas.
Methylal

- Safety concepts processing Methylal
- Major changes on foaming machines
Safety concepts processing Methylal

• Methylal belongs to the European middle class of flammability. It is highly but not extremely flammable like pentanes.

• Nevertheless, blends of polyols with useful amount of methylal for PU foams show high flash point.

• Methylal is usually co-blended with pentane. Safety concepts adopted are the same used for pentane.
Major changes on foaming machines

The devices used on foaming machines ready to use Methylal are the same used for machines ready to use Pentane.
Methyl Formate
Ecomate

- Safety concepts processing Methyl Formate
- Major changes on foaming machines
Safety concepts processing Methyl Formate

- Pure: Lower Explosion Limit higher than Pentane
  ➢ Storage tank, pipeline, etc. = Same safety rules as Pentane (for System Houses, Continuous Panel and Refrigerator producer)

- Blended to Polyol: no Flash Point as Pentane
  ➢ Foaming machine and foaming area = no safety is required as for Pentane

- It can be corrosive
  ➢ “Methyl Formate Kit” available for some parts of the Polyol line
Major changes on foaming machines

- **HIGH pressure machines:**

  1. **POLYOL METERING PUMP:** HYDROMATIK series (not RHL series), with a special anti-corrosion treatment and with stainless steel bearings.
  2. **DECREASE THE RPM:** using a double-polarity motor or using an inverter, so to avoid any overheating.
  3. **NOZZLE:** (only on the Polyol side), made of hard steel treatment (corrosion-proof)
  4. **VOLUMETRIC FLOW-METER:** replace with a stainless steel model, even better with a mass flow meter.
  5. **AVOID MAGNETIC COUPLING:** on polyol metering pump, thus reducing the heating.
Major changes on foaming machines

- **LOW pressure machines:**

1. **VOLUMETRIC FLOW-METER:** replace with a stainless steel model, even better with a mass flow meter.
2. **AVOID MAGNETIC COUPLING:** on polyol metering pump, thus reducing the heating.
HFOs

- Safety concepts processing HFOs
- Major changes on foaming machines
Safety concepts processing HFOs

- Boiling Point = +15 or +19°C (usually room temperature)

- A gentle “frothing effect” (very limited compared to R 134a – B.P. - 27°C) could be detected

- No needs of special equipments for safety. If co-blended with Pentane all safety measures for Pentane must be adopted.
Major changes on foaming machines

- Increase cooling circuit efficiency in the polyol side to process below 20°C
- Use a blending system suitable for LBA
- If co-blended with Pentane use the same devices related to Pentane
H2O

- Safety concepts processing H2O
- Major changes on foaming machines
Safety concepts processing H2O

- No needs of special equipments for safety.
Major changes on foaming machines

- No needs of any modification.

On final product:

- More consumption of PU
- Higher final density of the foam
- Less insulation efficiency (compared with other physical blowing agents)