Introduction of an Alternate Amine Catalyst

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Until recently, US foundries could chose between three aliphatic amines for curing cold box cores:

- Triethylamine – TEA
- Dimethylisopropylamine – DMIPA
- Dimethylethylamine - DMEA

Recently, suppliers have introduced a new option, DimethylIpropylamine (DMPA)

- This presentation reviews the characteristics of all four amine options
- Goal is to provide key data needed to allow selection of the best option

Safety First;
Key Hazards of Foundry Amines

- Flammable; potential explosion risk
- Inhalation exposure risk
- Corrosive, particularly to eyes

- Every employee must receive hazard communication training before working with amines

Safety First; Exposure Criteria

- TEA
  - OSHA PEL = 25 ppm (8-hr TWA; “legal limit”)
  - ACGIH TLV = 1 ppm, 3 ppm STEL
  - German AGW/OEL = 4.2 mg/m3 (1 ppm)
  - EU DNEL = 2 ppm (8.4 mg/m3)
- DMEA
  - DNEL = 1 ppm
  - TWA value 30 mg/m_3; 10 ppm (WEL/EH 40 (UK))
  - STEL value 46 mg/m_3; 15 ppm (WEL/EH 40 (UK))
  - NIOSH 88-103, December 1987; NIOSH Alert; Preventing Visual Disturbances and Acute Physical Distress Due to Dimethylethylamine (DMEA) Exposure
    - Recommends maintaining DMEA exposures below 2 ppm to avoid visual disturbances and systemic effects (headache, nausea, and stomach pain) during core making operations
- DMIPA
  - German MAK = 1 ppm (6.1 mg/m3) (TWA)
  - EU DNEL’s
    - worker: Long-term exposure- systemic effects, Inhalation: 3.6 mg/m3
    - worker: Short-term exposure - systemic effects, Inhalation: 7.2 mg/m3
    - worker: Long-term exposure - local effects, Inhalation: 3.6 mg/m3
    - worker: Short-term exposure - local effects, Inhalation: 7.2 mg/m3
    - worker: Long-term exposure- systemic effects, dermal: 0.9 mg/kg
- DMPA
  - EU DNEL’s
    - worker: Long-term exposure- systemic effects, Inhalation: 5.6 mg/m3
    - worker: Long-term exposure- systemic effects, dermal: 1 mg/kg
    - worker: Short-term exposure - systemic and local effects, Inhalation: 12.2 mg/m3
    - worker: Long-term exposure - local effects, Inhalation: 6.1 mg/m3

Safety First; Managing fire and explosion risks

- Leaks of amines represent a real explosion risk
  - Without high rates of ventilation, relatively small spills will generate a large, explosible vapor cloud
  - Evacuate in the event of larger releases
  - Maximize ventilation for all releases
- No ignition sources ~ 30 ft from potential release sources
- Use good Grounding & Bonding practices
- Train workforce to expect leak-free operations
  - Respond to odor complaints with high priority
- New & changed equipment: Check material compatibility
    - Carbon or stainless steel piping
    - Filled PTFE gaskets

Safety Considerations; Storage requirements

- Review NFPA 30 or the local fire code for storage requirements
- Storage indoors is subject to very significant requirements
  - Sprinklers, spill containment, etc.
  - For DMEA, provide continuous ground-level exhaust
- Most cost effective option is usually storage of a small number of cylinders in a low value shed
  - Exempt from sprinkler requirements and most other controls

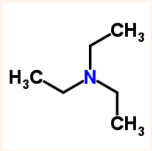
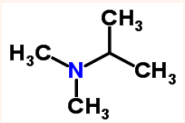
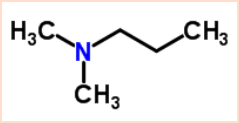
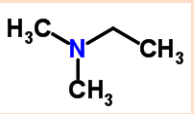
Desired Characteristics

- Reasonable cost
- Reliable supply
- Safe to transport, store and use
- Fast cure cycle
  - Optimal boiling point
  - Rapid diffusion
  - Fast, complete purge
- No nuisance conditions
- Minimal emissions/no permitting problems
- Good management options for process residuals

High-Level Comparison

	TEA	DMIPA	DMPA	DMEA
Cost	Lowest	Highest	Slightly lower than DMIPA	Medium
Reactivity	Lowest	Medium	Medium	Best
Odor	Fair	Fair	Fair	Worst

Key Data Comparison

	TEA	DMIPA	DMPA	DMEA
Structure				
Boiling Point	193 ºF	150 ºF	151 ºF	98.6 ºF
Flash Point	12.2 ºF	- 16.6 ºF	12.2 ºF	-32.8 ºF
Auto-ignition temperature	232 ºC (449.6 ºF)	190 ºC (374 ºF)	165 ºC (329 ºF)	206 ºC (403 ºF)
Bulk Cure(1) (%)(relative)	46 %	52 %	57 %	78 %
Explosive limits	1.2 – 8.0 %	1.0 – 8.1 %	1.1 – 9.0 %	2.3 – 12.0 %
Hazardous Air Pollutant?	Yes	No	No	No
NFPA Classification	1B Flammable Liquid	1B Flammable Liquid	1B Flammable Liquid	1A Flammable Liquid
Published Odor Threshold	0.5 ppm	1 ppm	0.07 ppm	0.007 ppm
Odor adherence (subjective)	Sticks	Sticks less	Sticks least	Sticks worst

(1) HAI TSR Report 14-5555520082 8/15/2014; Pct. of 1500 g sample coated sand solidified using 0.1 ml amine

DMPA vs DMIPA Trial

- **Comparison under commercial core production conditions**
  - **Trial conducted July 2014 at Laempe-Reich, Trussville Alabama**

Sand: Unimin 515 sand (63-70 ave. GFN; 3-4 screen)
Resin System: HAI Biocure 815 / 315
Resin level – 0.8 % @55:45 ratio
Dosing pump calibrated at 0.5 cc per stroke
Vaporizer control setting – 120 C
Vaporizer override setting – 140 C
No external purge air heater
Temperature out of vaporizer 146 F
2 cavity mold with a total blow weight of 49.24 pounds

DMPA v. DMIPA Core Gassing Trial

Material	DMIPA	DMPA	% Increase (decrease)
Pre-dose	40 strokes	38 strokes	(5)
Post-dose	4 strokes	4 stokes	-
Total Amine Dose	22 cc	21 cc	(4.5)
Gas/Purge time	13 seconds	12 seconds	(7.7)
Time to Final Pressure	5 seconds	5 seconds	-
Purge Pressure	5 bar	5 bar	-

1 stroke = 0.5 cc amine

Results

- *Zero broken cores*
- *No change to release agent application frequency or consumption*
- *DMPA odor was slightly better than DMIPA (per operators)*
- *Less amine odor in the cores (per operators)*
- *Facility elected to continue to run DMPA the next day and reported no issues and very similar results*
- *Laempe-Reich elected to switch to DMPA following the trial rather than going back to DMIPA*

Trial Conclusions

- **Switch from DMIPA to DMPA resulted in:**
  - **5.4% lower amine consumption**
  - **7.7% better cycle time**
  - **No decrease in good parts percentage**
  - **Lower core odor**
  - **Better workplace odor**

Before trialing or converting…

Ensure vaporizer high temperature safety shutoff is set for a maximum of 145 ^{o}C to provide an adequate margin of safety

I'm using TEA

- **Switching to DMPA would:**
  - **Eliminate HAP emissions from core production operations**
  - **Reduce consumption, particularly in Winter months or if gassing equipment is not optimal**
  - **Higher costs per pound offset by lower use**

I'm using DMIPA

- **Switching to DMPA would provide:**
  - **Slightly lower consumption**
  - **Possibility of reduced cycle time**
  - **Modest cost reduction**
  - **Improved odors and worker satisfaction**
    - **Lower core storage emissions/better purge**
    - **Lower absorption onto skin and clothing**

I'm using DMEA

- **Switching to DMPA would:**
  - **Reduce odors substantially**
    - **Less odor permeation/cling**
    - **Higher odor threshold**
    - **Far less unpleasant odor**
  - **Easier fire code compliance/ lower fire risks**
  - **May increase consumption and VOC emissions, particularly if vaporizer and gassing systems are sub-optimal**

- This example is for the newest style vaporizer found in Laempe Gas Generators
- Older gas generator vaporizers will have the thermal limiter adjustment accessible under the top cover
- The thermal limiter and temp control can be adjusted to the values in red below for use with DMPA.

The safety temperature limiter in the heater of the gas generators for DMEA, DMIPA and TEA were set to 170°C / 338°F. When using DMPA, the safety temperature limiter in the heater must be set to **max. 145°C / 293°F.** This is 20°C / 68°F below the auto-ignition temperature to avoid ignition inside the heater. The operational temperature controller should be set 20°C / 68°F below to limiter temperature to avoid limiter activity due to temperature spikes or peaks of the heater body.

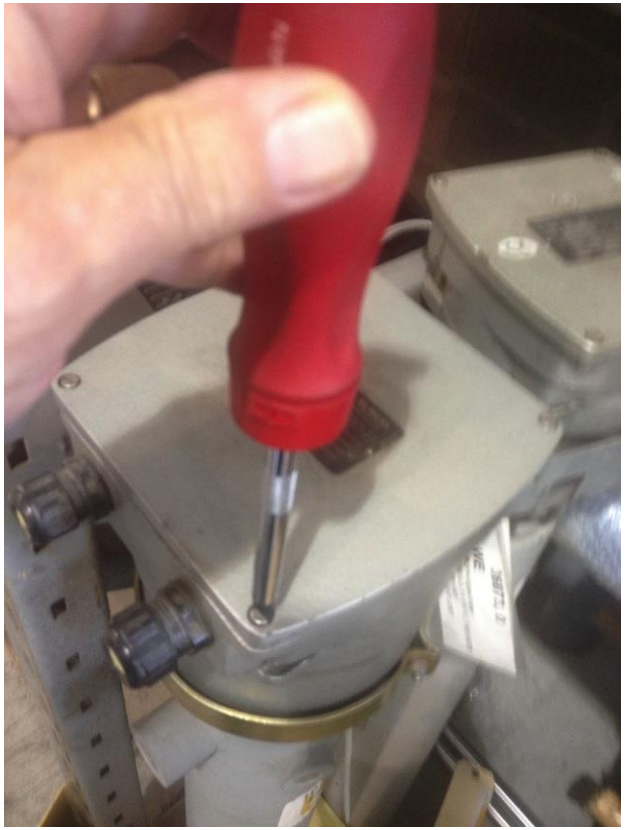
Following are the steps to access the thermal limiter in the Laempe Gas Generator Vaporizer. Before beginning any work follow proper lock out/tag out procedures, the gas generator vaporizer has 480 volts present inside the top section where you will access the thermal limiter adjustment.

Laempe Gas Generator
Cabinet Type

Internal view showing vaporizer

Laempe Gas Generator
LB/LFB Series Machine

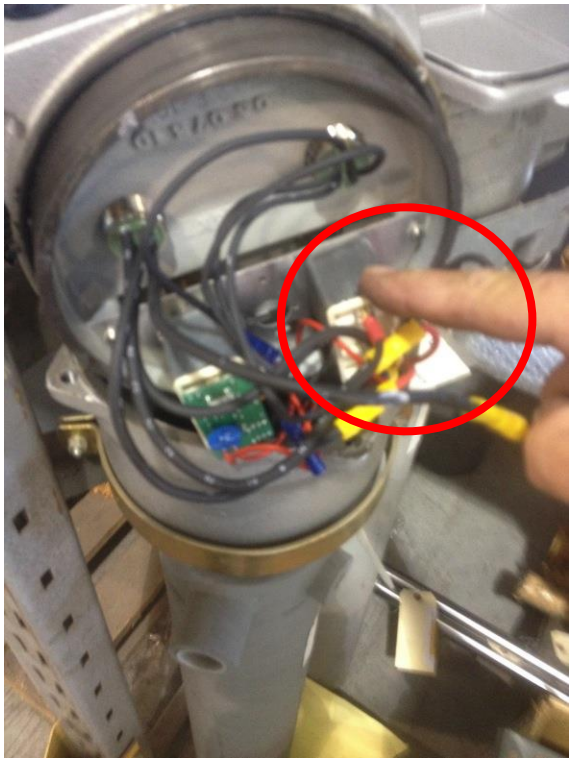
Internal view showing vaporizer



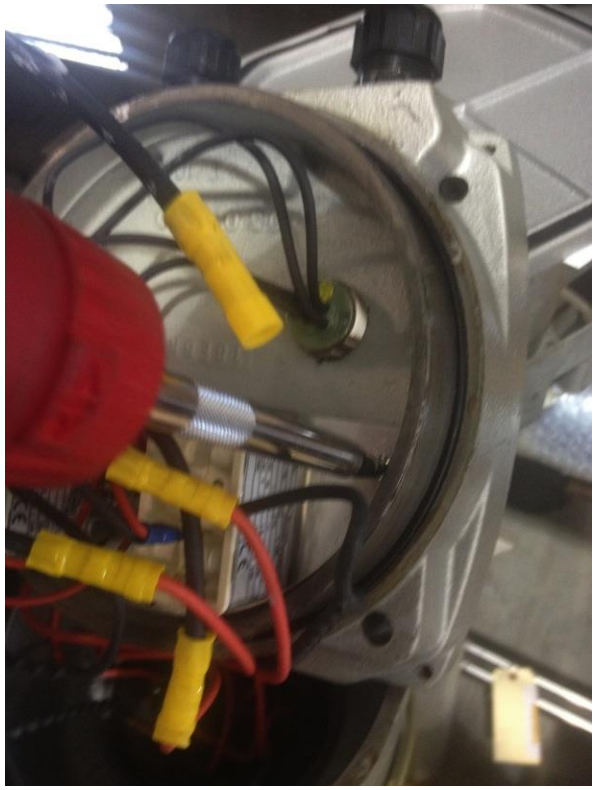
Remove top cover from vaporizer

Remove inner fiberglass cover

Remove the 4
Allen bolts holding
the control head
on the vaporizer



Remove the control head from the vaporizer, be careful not to damage the thermal probes and connections. The thermal limiter is shown here.



To access the thermal limiter adjustment remove the three screws holding the limiter mounting plate into the head cover, carefully lift out the plate.

Move the spring steel reset button strip to the side to expose the thermal limiter adjustment. If the thermal limiter is set too high for DMPA move the indicator to 145 degrees C maximum.

Reassembly in reverse order of disassembly. If there are any questions, or if you need any technical assistance, please contact Laempe Reich Technical Services at 205.655.2121
www.LaempeReich.com

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