

# **TBAc™ Solvent: A Cost-Effective Compliance Tool for the Graphic Arts Industries**



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**TBAc™ is a trademark of Lyondell Chemical Company**

# Outline

- **Solvent Use in Graphic Arts**
- **Regulatory Update**
- **t-Butyl Acetate VOC-exemption**
  - *Regulatory implementation*
- **TBAc Solvent Properties**
- **TBAc Solvent Potential Uses**
- **Information Sources**

# Where do you find solvents?

- **Inks (except litho)**
- **Press solvents**
- **Press cleaners**
- **Rubber rejuvenators (flexo)**
- **Fountain solutions (litho)**



# Common Pressroom Solvents

- **Toluene (publication and flexible packaging)**
- **Ketones (product and packaging)**
- **Glycol Ethers (cartons, screen inks)**
- **Esters (product & packaging)**
- **Alcohols (packaging)**
- **White Spirits (textile screen inks)**

# Issues with Solvent Use

- **Environmental**
  - *Smog (ozone) formation (VOCs)*
  - *Hazardous Air Pollutants (HAPs)*
- **Worker Health & Safety**
  - *Over-exposure*
  - *Flammability*
- **Regulatory**
  - *Hazardous Air Pollutant Regulations*
  - *VOC Regulations*
  - *OSHA & NIOSH Regulations*

# What is a HAP?

- Any compound listed by the EPA as a Hazardous Air Pollutant based on its toxicity and use.
- HAP list: [http://www.nescaum.org/committees/CEP\\_Dec1/HAPlist.html](http://www.nescaum.org/committees/CEP_Dec1/HAPlist.html)
- HAPs include:
  - *Toluene & xylene*
  - *Some ketones (eg. MEK, MIBK)*
  - *Methanol*
  - *Glycol ethers based on ethylene glycol (except EB)*
  - *Several halogenated solvents (PERC, TCE, MC)*
  - *Hexane*

# What is NOT a HAP?

- Any solvent that is not on the HAP list.
- Non-HAP solvents include:
  - *Most ketones (eg. Acetone, MPK, MAK)*
  - *Most alcohols (eg. ethanol, propanols)*
  - *Glycol ethers based on Propylene Glycol (eg. PM, PMA)*
  - *Glycol ether EB*
  - *Esters (eg. Ethyl & propyl acetate, TBAC solvent)*
  - *Most aliphatic hydrocarbons (mineral oils and spirits)*

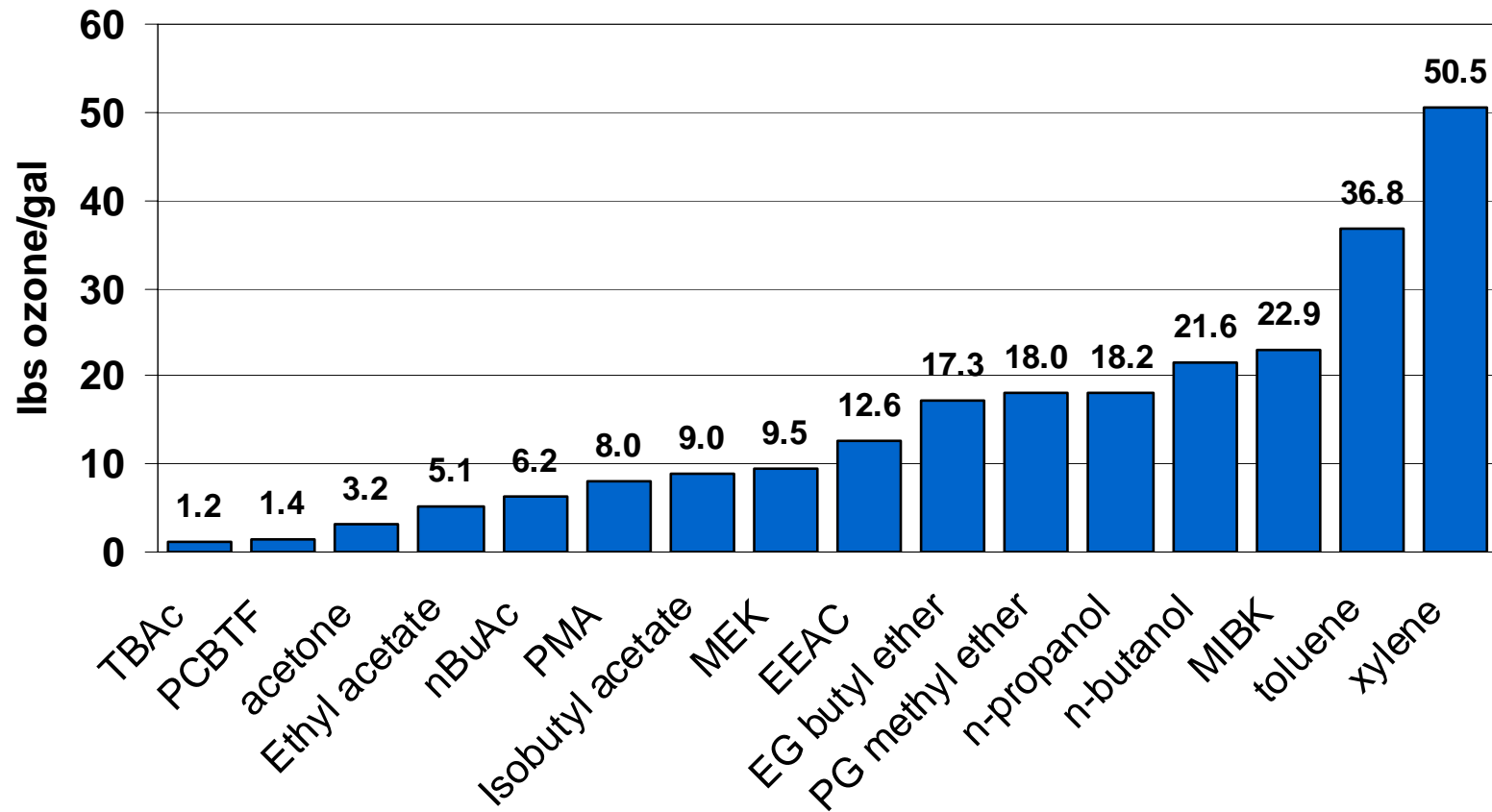
# What is a VOC?

- Any organic compound that contributes to smog (ozone) formation.
- There is no list of VOCs.
- VOCs include:
  - *Toluene & xylene*
  - *Most esters (eg. propyl and ethyl acetates)*
  - *Most ketones (eg. MEK, MIBK, MPK)*
  - *All alcohols (eg. propyl and isopropyl)*
  - *All glycol ethers*
  - *All hydrocarbon solvents*

# What is NOT a VOC?

- Compounds specifically listed as VOC-exempt.
  - [http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2004\\_register&docid=fr29no04-8.pdf](http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2004_register&docid=fr29no04-8.pdf)
- Compounds are exempted if they produce less ozone than ethane.
- VOC-exempt solvents include:
  - *TBAC*
  - *Acetone*
  - *Methyl Acetate*
  - *Several halogenated solvents*

# Ozone-forming Potential of Common Solvents



...the products of which are less ozone than toluene

# What is TBAC Solvent?

- Tertiary-Butyl Acetate
- An ester solvent similar to n-propyl acetate
- A good solvent for several ink resins
- An potential alternative to toluene in publication gravure inks
- An alternative to HAP and VOC solvents in packaging and product inks

# CAA Regulations for Gravure Printers



- **Printing & Publishing NESHAP (1995)**
  - ***EPA-453/R-95-002a***  
***(<http://www.epa.gov/ttnuatw1/print/prpbbid.pdf>)***
  - ***Limits HAP emissions from major sources (> 10 or 25 tons per year)***
  - ***92% control for publication***
  - ***95% control for packaging & product***
- **Graphic Arts CTG**
  - ***VOC control in non-attainment areas***
  - ***65% control for packaging & product***
  - ***75% control for publication (84% control for new sources)***
  - ***or use inks with  $\leq 25\%$  VOC or 60% solids***

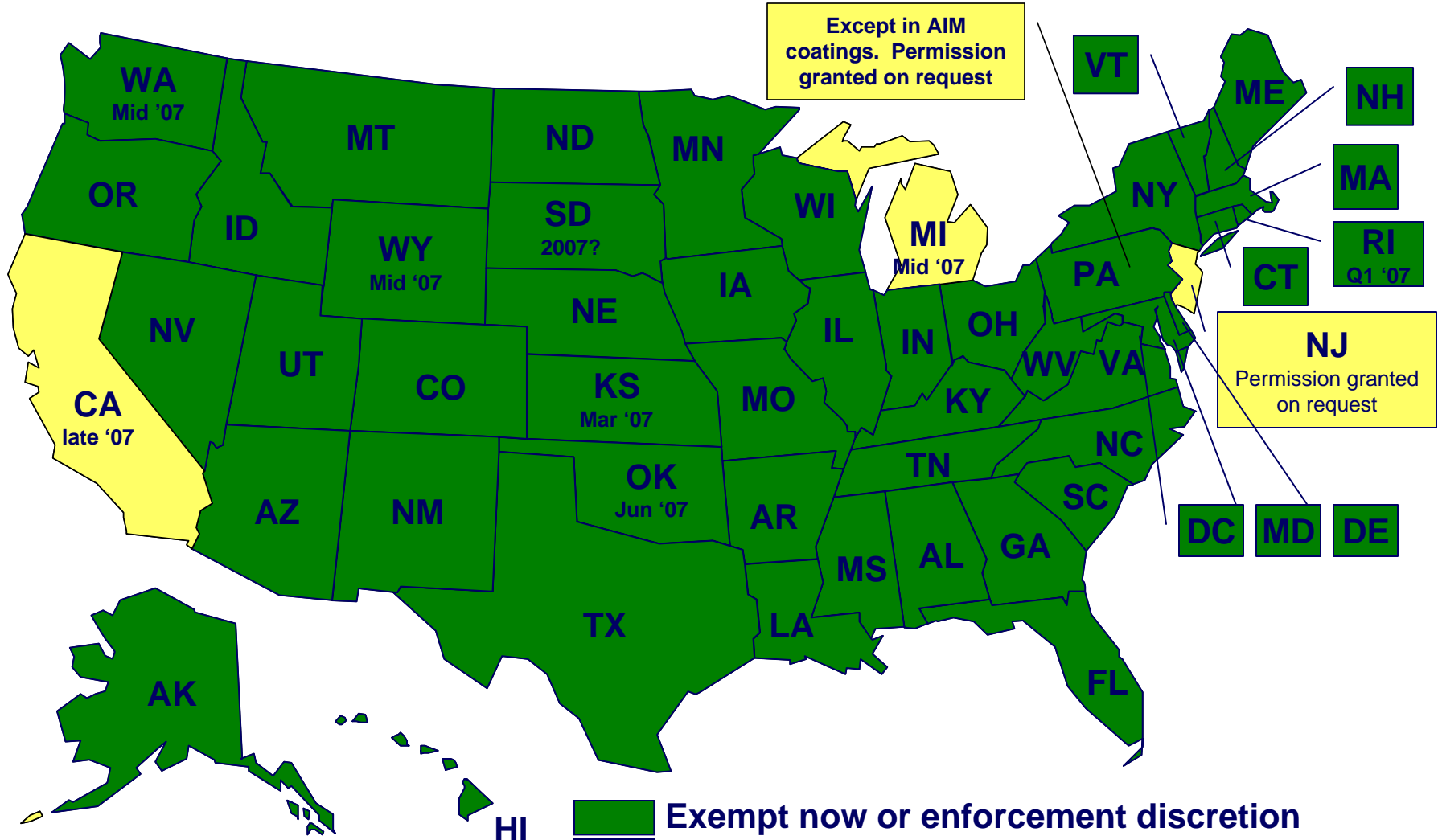
# Regulatory Update

- **November 29, 2004**
  - *EPA publishes final rule adding t-butyl acetate to list of VOC-exempt compounds.*
  - *Glycol ether EB (EGBE) removed from list of Hazardous air pollutants*
- **t-Butyl Acetate exemption became effective December 29, 2004**
  - *For all federal rules not superseded by more stringent State or local rules.*
  - *t-Butyl Acetate not a VOC for purposes of VOC emissions limitations or product content limits.*
  - *t-Butyl Acetate continues to be a VOC for recordkeeping, emissions recording, and inventory requirements.*

# State Exemption Processes

- Automatic exemptions
  - *Federal definition adopted “by reference, by date”*
  - *Exemption usually simultaneous with federal rule*
  - *Exemption may be procedurally delayed*
  - *Local, County, or District rules may supersede*
- Rulemaking required
  - *Rulemaking initiated at State’s discretion*
  - *Process similar to federal exemption process*
  - *Process can take several months to a couple of years*
  - *Some states may grant “interim relief”*

# TBAC State VOC Exemption Status – 01/08/2007



- Exempt now or enforcement discretion
- Limited exemption or action required
- Not exempt

# Compliance Options

- Reduce or eliminate solvent use
  - *Can affect performance*
  - *Can affect ink costs*
  - *Capital often required*
  - *Creates new environmental impacts*
- Recover or incinerate emissions
  - *Capital & energy required*
  - *Incineration can generate NO<sub>x</sub>, CO*
- Reformulate to non-HAP, VOC-exempt solvents



Solvent Recovery System

Photo courtesy of Waterlink  
Barnebey & Sutcliffe

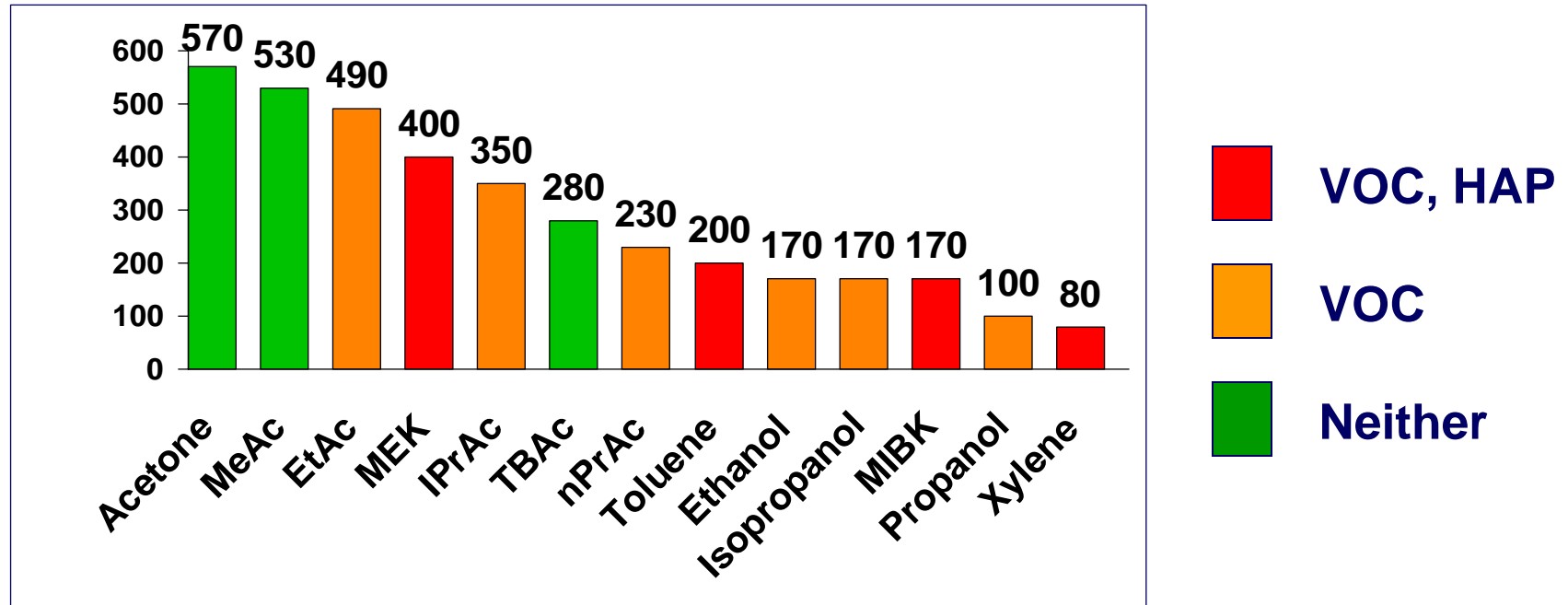
# Potential Benefits of Solvent Substitution

- **Can change source classification for the better**
- **Few or no process changes**
- **No new equipment required**
- **No operator re-training necessary**
- **Less paperwork**
- **Lower exposure hazards**
- **No NO<sub>x</sub>, CO, or CO<sub>2</sub> formation**

# TBAc Solvent Properties

- **Broad solvency**
  - *coating, ink, adhesive resins*
  - *soils, greases*
- **Evaporation rate similar to toluene & n-propyl acetate**
- **40°F flash point higher than acetone and methyl acetate**
- **Low density**
- **Low predicted environmental impact and persistence**
- **Low acute and chronic toxicity**

# Evaporation Rates of Ink Solvents



TBAC solvent is slower than acetone or methyl acetate

# TBAc Solvent Potential Uses

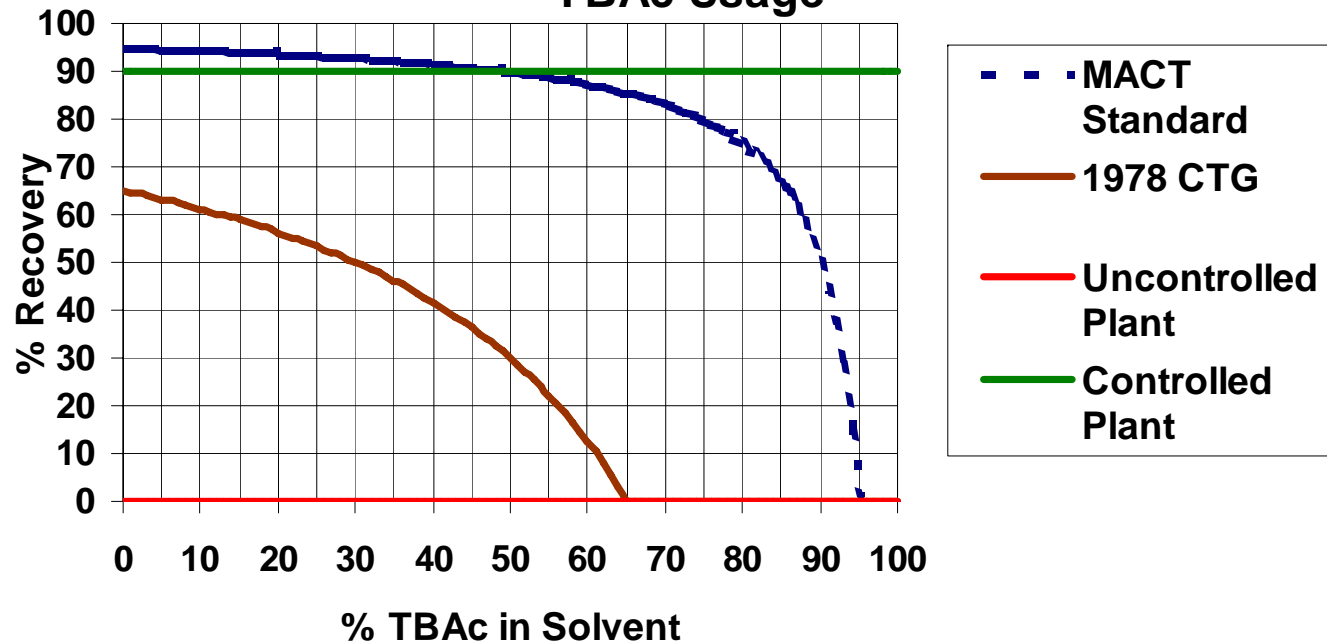
- Cleaners
- Thinners
- Solvent-based Inks
  - *Flexographic*
  - *Gravure*
- Overprint varnishes
- Laminating adhesives

# Case # 1: Flexible Packaging Gravure

- Packaging Industry uses a variety of solvents:
  - *Toluene, alcohols, esters, ketones...*
- Both HAPs and VOCs are used.
- Inks based on a variety of resins:
  - *nitrocellulose, polyamide, acrylic, vinyl, urethanes*
- Most of the ~350 facilities use incineration.
- Required to control 65% VOCs and 95% of HAPs
- Some facilities use zero HAPs.

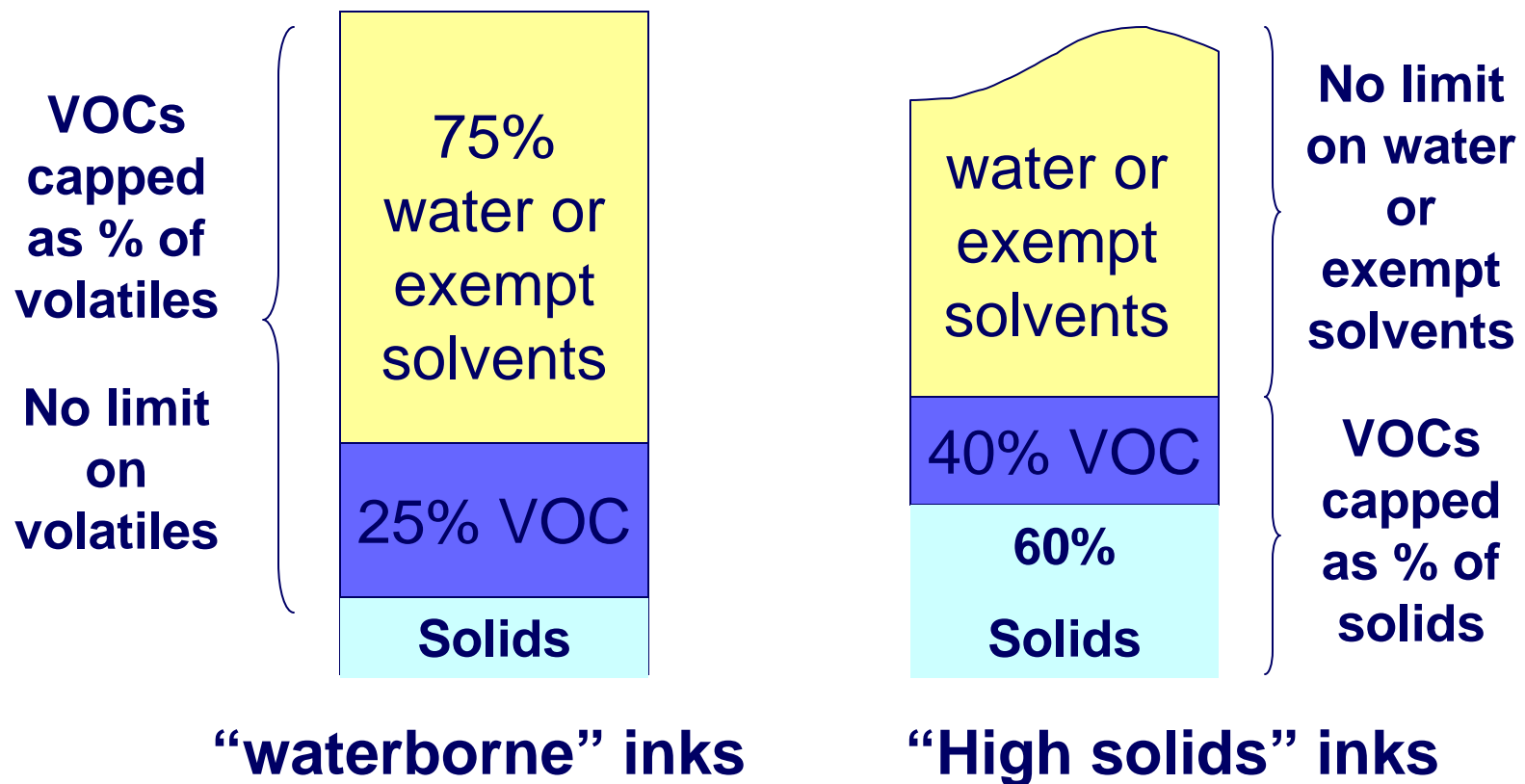
# Compliance Option A: Control Emissions

**% HAP & VOC Recovery Required for Major Sources in Product and Packaging Gravure vs TBAC Usage**



**TBAC solvent may help - subject to RACT approval**

# Compliance Option B: Reformulate

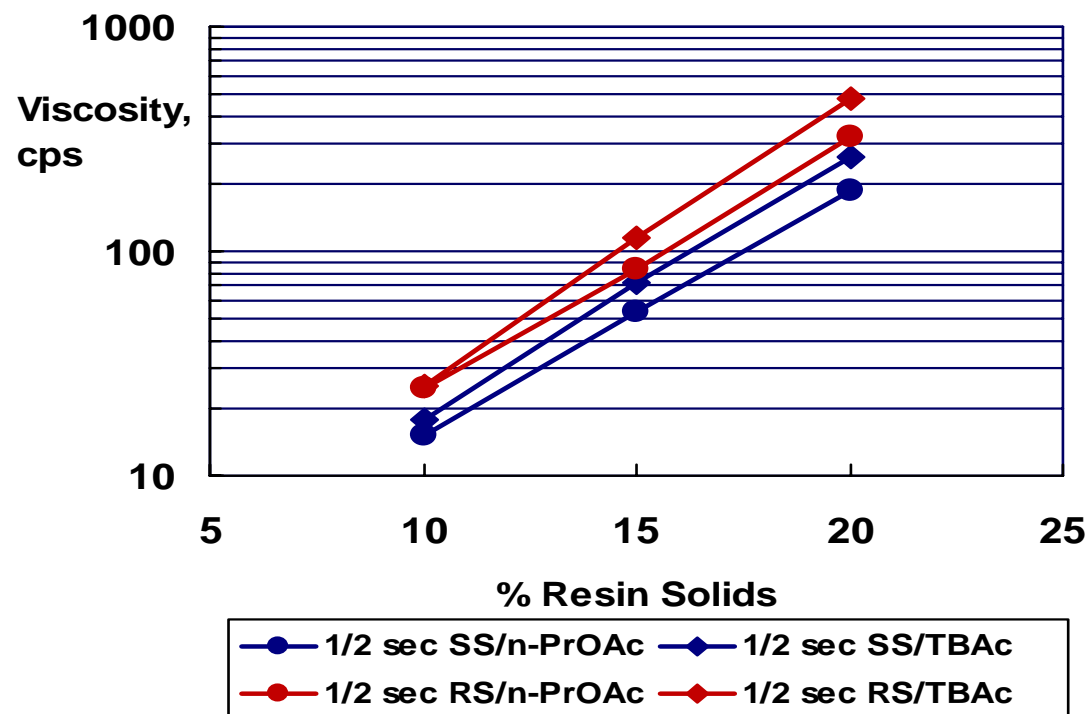


# Matching Evaporation Rates

<b>Solvent</b>	<b>ASTM evaporation time seconds</b>	<b>Evaporation Rate vs n-BuAc</b>	<b>VOC &amp; HAP Compliant Alternative</b>
Methanol	230	2.1	65/35 TBAc/Propanol
Ethanol	296	1.6	65/35 TBAc/PM
Isopropanol	328	1.4	65/30/5 TBAc/PM/PNP
Propanol	550	0.9	65/25/10 TBAc/PM/PNP
Toluene	236	2.0	65/35 TBAc/Propanol
Ethylbenzene	554	0.9	65/35 TBAc/PM Acetate
Xylene	673	0.7	65/35 TBAc/PM Acetate
Ethyl acetate	115	4.1	65/35 TBAc/Methyl Acetate
Isopropyl acetate	138	3.4	75/25 TBAc/Methyl Acetate
Propyl acetate	205	2.3	65/35 TBAc/Isobutyl Acetate
MEK	124	3.8	60/40 TBAc/acetone
MIBK	293	1.6	65/35 TBAc/n-Butyl Acetate

**Simple non-HAP blends can approximate solvent rates**

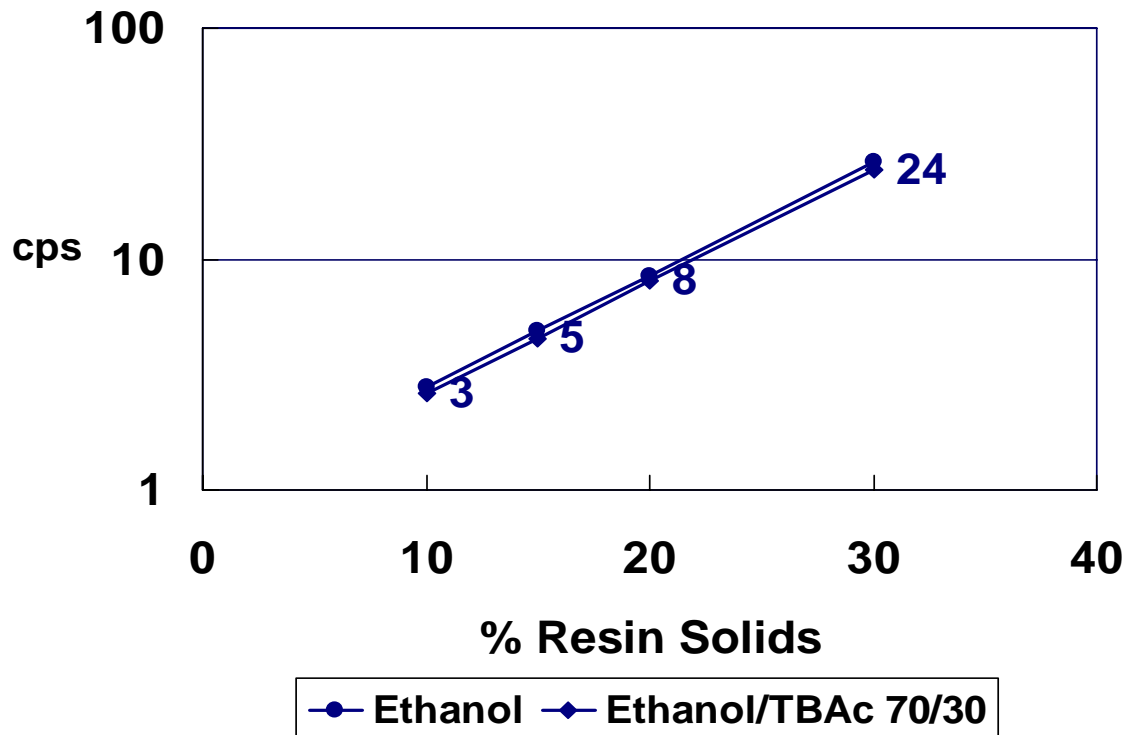
# Example # 1: Replacing n-Propyl Acetate in Packaging Gravure Inks



**TBAC solvent is an active solvent for nitrocellulose**

# Example # 2: Replacing Ethanol in Packaging Gravure Inks

Viscosity of Alcohol Soluble Polyamide Solutions



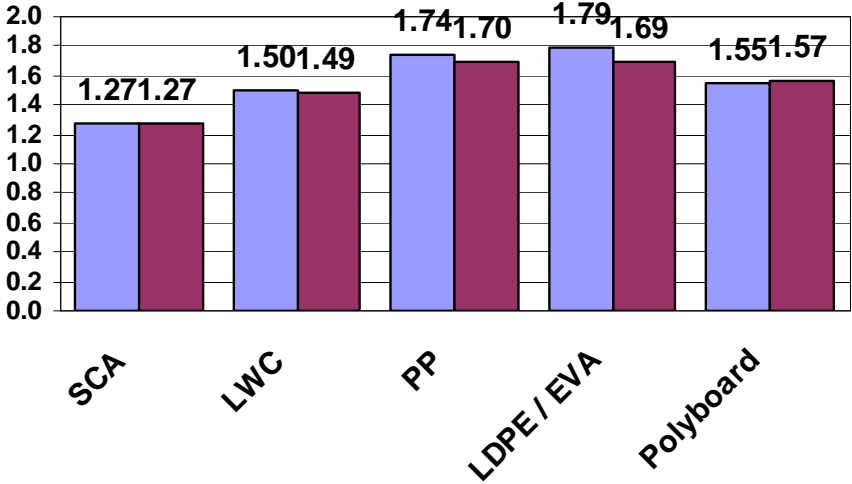
TBAc solvent is an active solvent for polyamide resins

## **Printability of TBAC Solvent-based Packaging Gravure Ink**

- **Compared TBAC solvent to n-Propyl acetate.**
- **Testing performed at Western Michigan University.**
- **Black pigment reduced to print viscosity.**
- **Less TBAC solvent required at print viscosity**
- **Inks applied to 5 plastic substrates.**
- **TBAC solvent gave slightly better gloss and print density.**
- **Rub resistance was identical.**

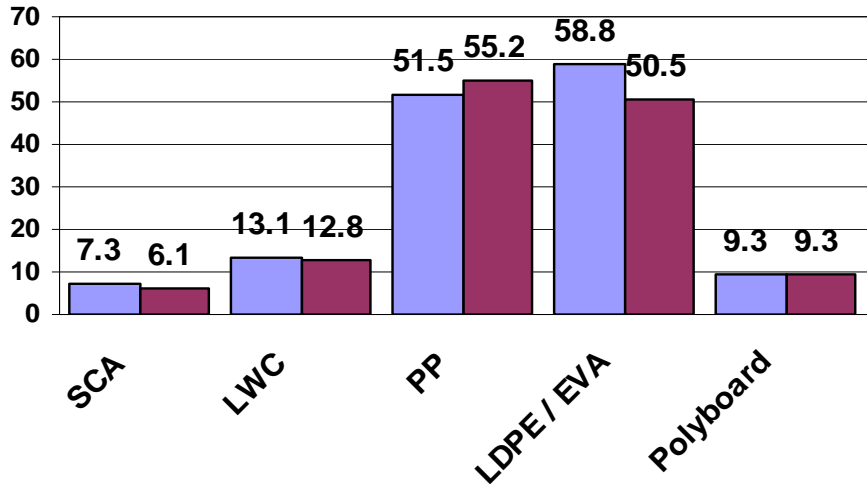
# Use of TBAC Solvent in Packaging Gravure Ink

Print Density



TBAC n-Propyl Acetate

Gloss



TBAC n-Propyl Acetate

TBAC solvent-based ink print quality similar to propyl acetate

## Use of TBAC Solvent in Packaging Gravure Ink

- TBAC solvent is a good solvent for packaging inks.
- Evaporation rate close to n-Propyl acetate.
- 85/15 TBAC/nBuAc is a match.
- 75/25 TBAC/VOC blends will be compliant.
- No changes in process required.
- Emission controls not required.

## Case Study #2: Use of TBAC Solvent in Product Gravure Inks

- **Constant Services Inc. (CSI) prints 500 colors a week on vinyl.**
- **Use “70/30” blend in some inks and as letdown solvent.**
- **Blend contains TBAC solvent.**
- **No problems with “70/30” blend after 3 years.**

## Case Study # 3: Use of TBAC Solvent for Publication Gravure Printing

- Industry uses toluene-based inks.
- Toluene is both a HAP and a VOC.
- Inks optimized for toluene.
- All facilities use carbon absorption.
- Several facilities use PTEs.
- Recovery efficiency between 80 and 99%.
- Recovered solvent reused at press or sold.

## **Case Study # 3: Use of TBAC Solvent as Letdown Solvent for Publication Gravure Ink**

- **Preliminary testing performed at WMU.**
- **Compared TBAC solvent to toluene.**
- **Four color process inks reduced to print viscosity.**
- **Slightly more TBAC solvent is required to achieve print viscosity.**
- **Inks applied to 38# LWC and 34# SC paper.**
- **TBAC solvent and toluene gave similar print density.**
- **Toluene gave slightly better gloss.**

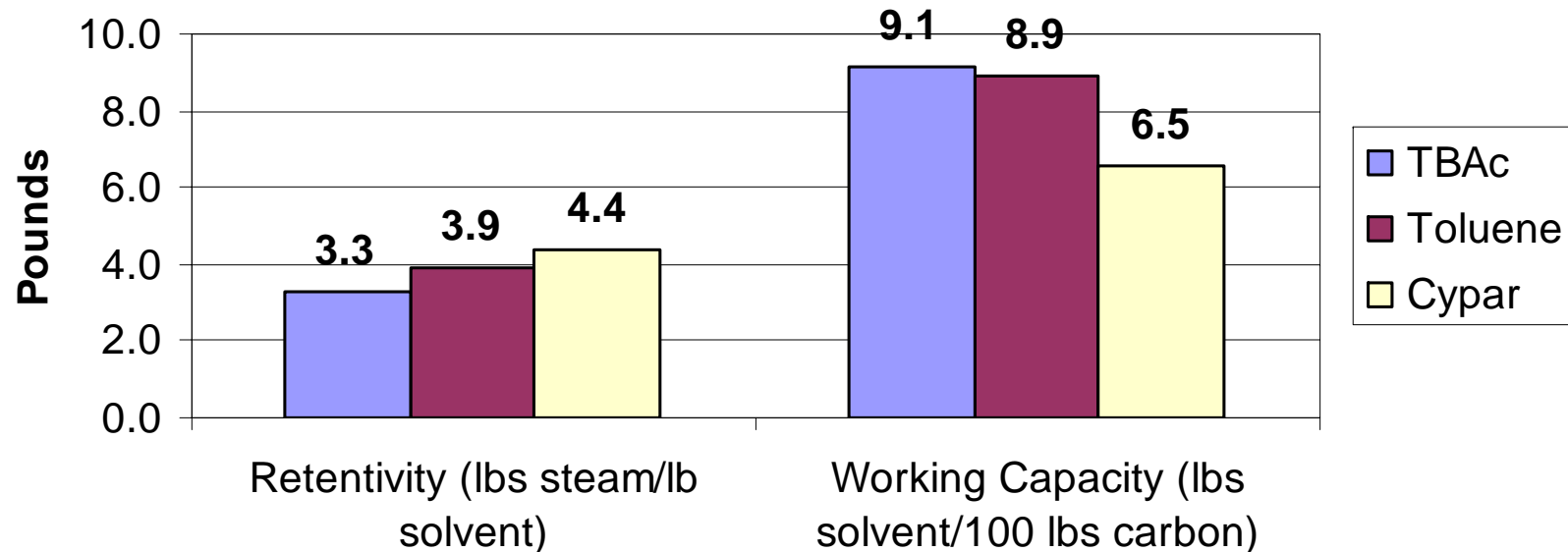
## **Case Study # 3: Use of TBAC Solvent as Letdown Solvent for Publication Gravure Ink**

- **Commercial inks optimized for toluene**
- **Resinates can be prepared in TBAC solvent**
- **TBAC solvent gives similar print density**
- **TBAC solvent gives slightly lower gloss**
- **TBAC solvent evaporation rate faster than toluene**

**Need to optimize resins & ink formulations**

## Case Study # 3: TBAC Solvent is Easier to Recover than Toluene or Cypar™ (Barnebey & Sutcliffe)

### Solvent Recovery and Desorption on Grade 207E4 Activated Carbon Pellets



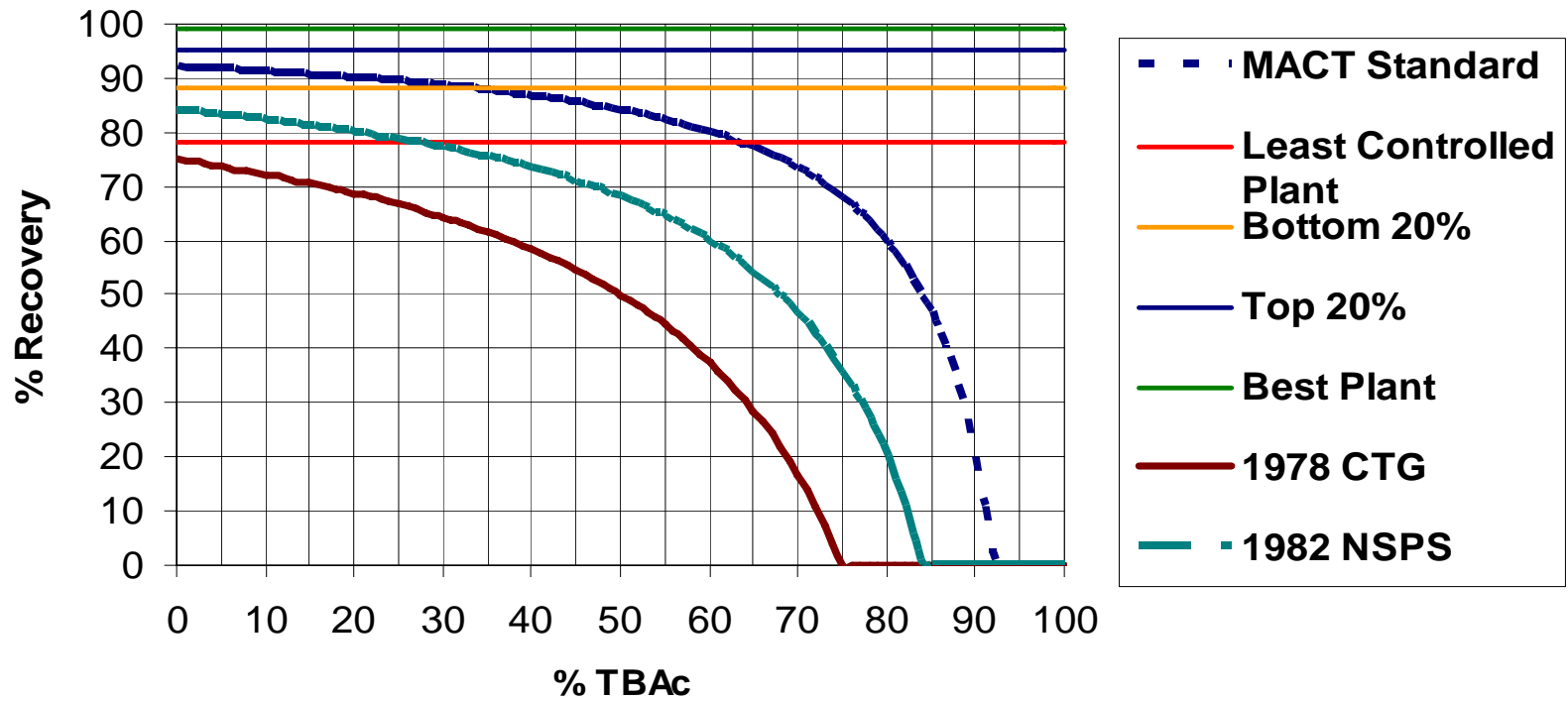
**TBAC could reduce recovery costs**

## **Case Study # 3: Use of TBAC Solvent in Publication Gravure Ink**

- **TBAC solvent could reduce HAP and VOC emissions at printers, ink producers, and resinate producers.**
- **New source permitting may be simplified.**
- **Solvent costs would be higher.**
- **Energy costs could be lower.**
- **Print quality may be unchanged.**

# Potential Solvent Substitution Benefits

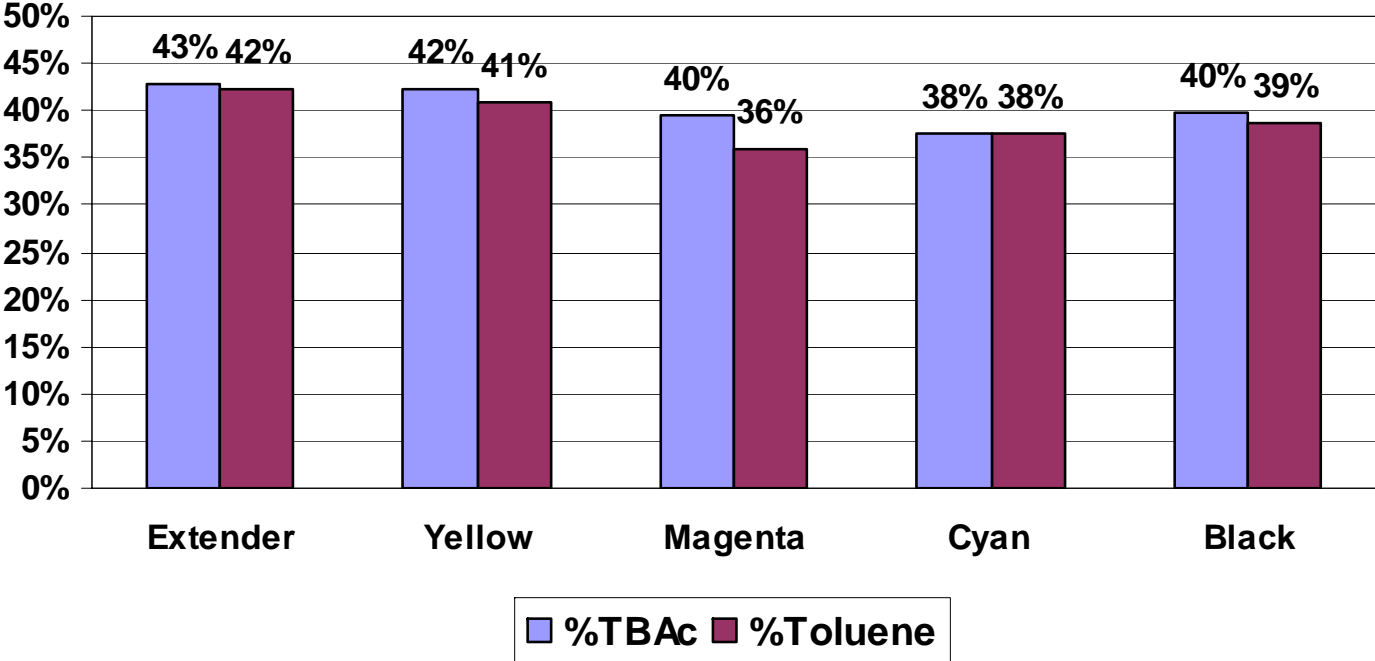
## % HAP and VOC Recovery Required for Publication Gravure vs TBAc Usage



Lower Recovery Requirements

# Case Study # 3: Use of TBAc Solvent as Letdown Solvent for Publication Gravure Ink

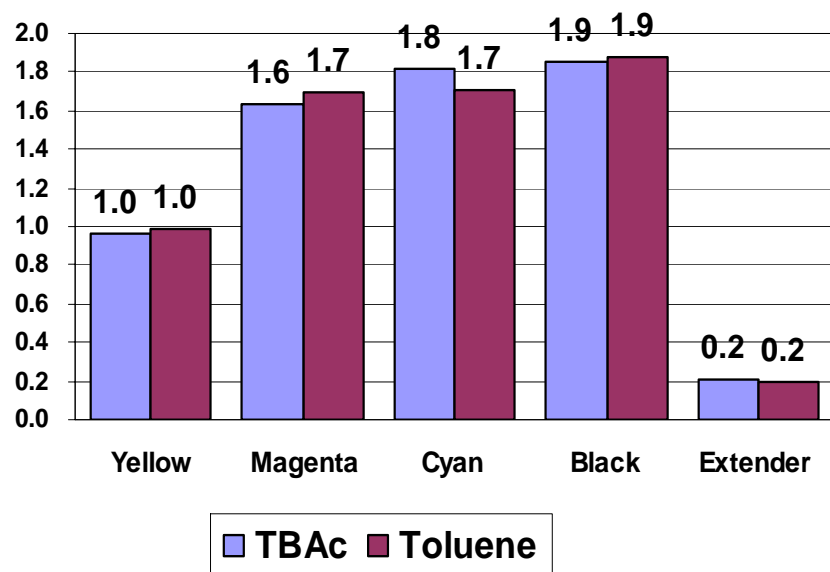
% Solvent at Print Viscosity of 19 Seconds (Shell #2 Cup)



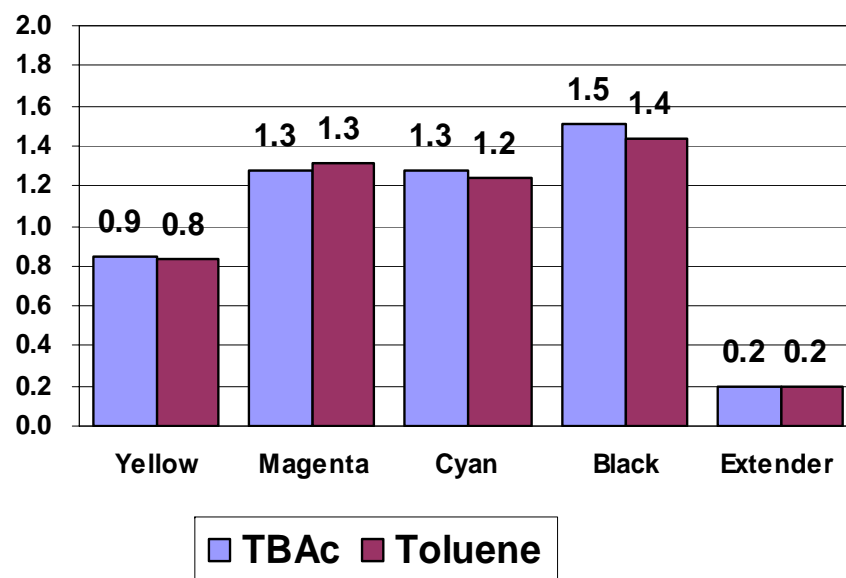
Slightly more TBAc required to achieve print viscosity

# Case Study # 3: Use of TBAc Solvent as Letdown Solvent for Publication Gravure Ink

Print Density on 38# LWC Paper



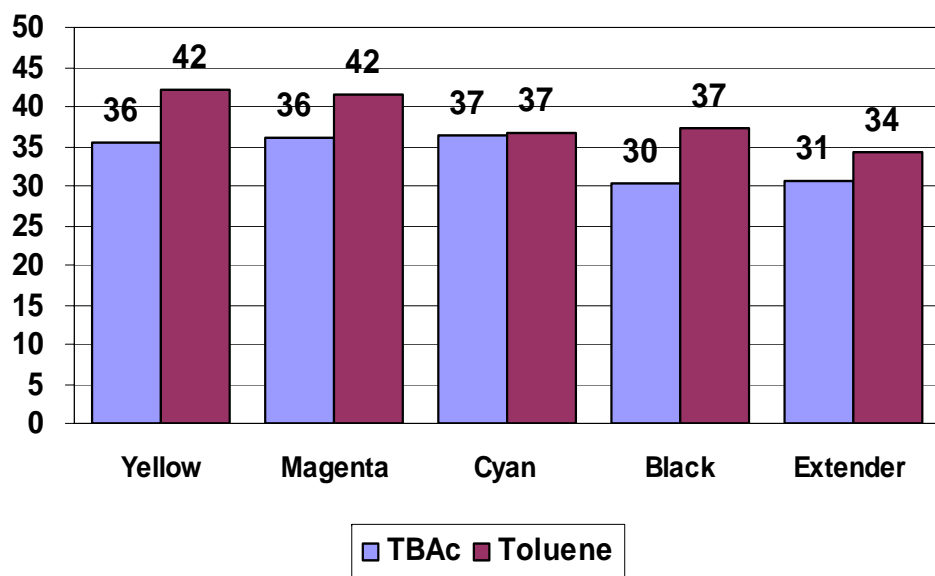
Print Density on 34# Supercalendered Paper



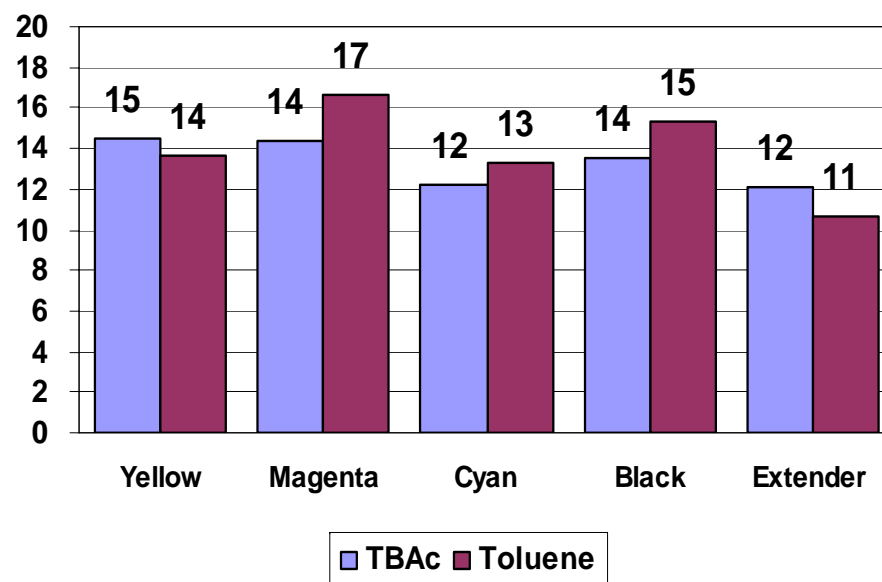
**TBAc solvent gave good print density.**

# Case Study # 3: Use of TBAC Solvent as Letdown Solvent for Publication Gravure Ink

Ink Gloss on 38# LWC Paper



Ink Gloss on 34# Supercalendered Paper



**Toluene gave slightly better gloss.**

## Conclusions

- Solvent substitution is a viable compliance tool.
- In 2004, EPA published a final rule exempting non-HAP TBAC from VOC regulations.
- States and Local Districts changing their VOC definitions
- TBAC solvent works in product gravure inks.
- Studies show that it could replace:
  - *N-Propyl acetate or ethanol in packaging inks.*
  - *Esters, alcohols, and ketones in product inks.*
  - *Toluene in publication gravure*

# TBAc Solvent Information

- [www.tbac.com](http://www.tbac.com)
- General questions & samples:
  - 888-777-0232
  - [TBAc@lyondell.com](mailto:TBAc@lyondell.com)
- Commercial questions:
  - Gail Kelly: 610-359-6443 [gail.kelly@lyondell.com](mailto:gail.kelly@lyondell.com)
- Technical & Regulatory questions:
  - Dan Pourreau: 610-359-6837 [dan.pourreau@lyondell.com](mailto:dan.pourreau@lyondell.com)
  - Gail Kelly: 610-359-6443 [gail.kelly@lyondell.com](mailto:gail.kelly@lyondell.com)

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