Global PVC Stabilizer Trends for Pipes – Challenges and Practical Experience

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Agenda

- Overview PVC pipes, stabilizers and markets
- Worldwide trends for PVC pipes
- Cost as critical driver
- Market trends for cost reduction
  → High filler level
  → Multi-layer pipe
  → More effective use of onepacks
- Summary
Growth has come in the Developing Markets

Global PVC Consumption 2011 Pipes (Ktons)

- **North America**: 2,000 Ktons, G.R. 1-2%
- **South America**: 650 Ktons, G.R. 3-5%
- **Middle East/Africa**: 1,200 Ktons, G.R. 6%
- **Europe**: 1,700 Ktons, W Eu G.R. 0-2%, CE Eu G.R. 6-8%
- **India**: 1,400 Ktons, G.R. 7-9%
- **Asia**: 1,500 Ktons, G.R. 2-3%
- **China**: 3,400 Ktons, G.R. 9-11%

Total: 11,850 Ktons

Source: Baerlocher Estimate/approximations
Pb-Stabilization dominates PVC pipe systems globally

Source: BAERLOCHER ESTIMATE
Ca-based systems are now the standard in Europe

Source: BAERLOCHER ESTIMATE

Tin stabilizers still dominate in North America

- Tin stabilizers
  - Best price/performance ratio for white coloured pipes
- FDA regulates material for food contact application
  - NSF-standard and certification for pipes
- Drinking water pipes ➔ Max 1 part of Sn per 100 parts of resin
- California as leader in material restriction
- Rarely tests with Ca-based systems
Trends towards Ca-based stabilisers in South America

- Pb-based systems dominating in Uruguay, Argentina, Paraguay, Bolivia → Trend however to Ca/Zn
- Columbia, Venezuela, Ecuador using Sn
- Peru is using Pb, Ca/Zn as well as Sn depending on the company
- Brazil: Ca-based systems dominate
- Health authority is pushing against Pb for potable water
Pb systems dominate in Asia (but with some trends to Ca-based)

- Focus on Pb (small amounts on Sn, Ca-based, no regulation for Pb-free)
- China → Potable water pipe (Pb-free) (Goal: Pb-free for U-PVC)
- Korea/Australia/New Zealand → U-PVC pipe (Pb-free)
- Trend setters: China / Australia / New Zealand
- Main trend to Ca-based
Pb systems dominate in India (limited volumes in Ca-based)

- Generally Pb-based, except for plumbing pipes small trend to Ca/Zn
- No regulations for drinking water application
  → Industry prefers Pb (cost-effective)
- Ca/Zn used by selected pipe producers but not promoted due to relative high costs
In general Pb stabilisers are used in M. East/Africa (certain regions trending to Ca-based)

- Pb-based stabiliser systems dominating for pipes
- Drinking water pipe has to be free of Pb, As, Cd, Cr (Ministry of Health, Iran)
- Sn and Ca-based systems on small usage level
- Slight trend towards Ca-based
- Ca-based systems present in Northern countries of Africa and South-Africa
Cost is driving development in PVC pipes

- Worldwide trends to more cost-efficient production of PVC pipes
  → Cost is the critical driver

- Possibilities for cost reduction
  → High filler level
  → Multi-layer pipe
  → More effective use of onepacks
Increased filler content can reduce cost

Pipe markets with high filler level applications

- Europe
  - e.g. Italy: up to 60 phr

- MEA
  - Middle East: up to 50 phr
  - Africa: up to 30 phr

- China
  - filler level up to several hundred phr !?!
Increased filler content effects preparation and performance

Aspects of high filler levels in PVC-U applications

- Preparation of dryblend
  - Homogeneity / Free-flowing properties / Deposits / Segregation

- Processability
  - Bridging / Gelation behaviour / Abrasion

- Products
  - Mechanical Properties / Colour / Cost
Stabiliser systems can be modified to allow for increased filler loadings

Development trends for high filler formulations

→ Adaptation of stabilizer system to high filler level

■ Internal / external lubricants
  (e.g. waxes, paraffins, ester waxes)

→ Incorporation of filler

→ Improved processing

■ Adaptation of dosage for pigmentation
The type of filler utilised effects performance

Filler – Types and Effects

- **Positive effects of fine grades**
  - Promoted gelation behaviour
  - Higher quantity of \( \text{CaCO}_3 \) particles
  - Higher regularity of foam structure

- **Positive effects of coated filler**
  - Improvement of free flowing properties
  - Lower friction of the polymer melt

- **Mechanical properties**
  - Increase of stiffness through higher \( \text{CaCO}_3 \) content
    (\( E \)-modulus, ring stiffness)
Cost reductions by use of multi-layer extrusion is widely seen

Facts

- 3-layer pipe: usage of recycled material in the intermediate layer (1st extruder: inner/outer skins, 2nd extruder: foam)
- Reduction in weight (density: ~ 1.4 → ~ 1.0 g/ccm)
- Lack of recycled PVC → usage of virgin PVC and introduction of foaming process → saving of raw material
- Main Application: Pressureless sewage pipes
Easy melt flow necessary for skin-layer

Extrusion Process I

- Two extruders: different requirements for plastification and viscosity for foam and skin layer:

- Skin:
  - Low melt viscosity to guarantee easy melt flow in tight die-head channels
  - High external lubrication to ensure good metal release, due to long flow paths
  - But: high external lubrication prevents good plastification
  → solution: oxidised waxes
Extrusion Process II

- Two extruders: different requirements for plastification and viscosity for foam and skin layer:

- Foam:
  - Perfectly balanced viscosity (lubricants / processing aid) to ensure easy foaming and high bubble stability
  - Adequate energy absorption (torque) to ensure good dispersion of blowing agent
  - Relative high melt pressure to ensure good foaming
    - Adjustment of perfect gelation time, depending on type of blowing agent and type of extruder/screws!
Low foam density is a key factor in multi-layer pipes

Adjustment of multi-layer foam core formulations

■ Foam layer:

Define a perfect balance of …

• dosage of chemical foaming agent
• plastification time
• mass pressure and temperature
• amount of PVC in the foam layer
• amount and type of processing aid

… to achieve low foam density (costs!)

→ Baerlocher provides tailor-made solutions
Higher filler level in foam core pipes can improve performance of processing and pipes

High filler level in foam core pipes

- Effects of high filler level in foam (16 → 30 phr) and skin layer (16 → 20 phr)
  - Stable foaming process
  - Well-balanced ratio of skin & foam layer thickness
  - Disappearance of slight waves in the inner layer
  - Good foam density (0.75 g/cm$^3$)

- Filler level of 40 phr in Foam → Bridging effect of the dryblend
Higher filler levels as trend in multi-layer pipes

Trends in multi-layer pipes

- Basic stabilizer for compact pipe can be used as starting base for foam core pipe
  - Adjustments (internal/external lubricants) necessary for foam core pipes

- Increased filler level / direct addition of filler for (foam core) pipes
  - Positive effects not only to reduce raw material cost but also on processing and properties of pipes
Basic stabilizer onepacks can reduce cost and improve flexibility in production

- Trend of pipe and fitting producers to use colourless Baeropan onepacks for more flexibility in regards of colouration
- Ca-based core stabiliser for dark colours + booster for light coloured applications
- Basic stabiliser for compact pipe can be used as starting base for other pipe applications
Summary

- Pipe market growing in Developing Markets
- Europe: Clear Ca-based
- Critical driver: Cost → Solutions to reduce cost:
  → High filler level
  → Multi-layer pipe
  → More effective use of stabiliser onepacks
Baerlocher provides tailor-made solutions for your pipe application

static/dynamic thermostability

rheology

colour hold

initial colour

... from dark ...

... to light coloured applications ...