

Criteria for selecting dozes for thermal stabilizer in PVC compound.

1. Unstable nature of PVC

- By nature, PVC is thermally unstable polymer, as compared to other thermoplastics.
- This is because the activation energy for thermal degradation of PVC is 20 Kcal/mole which **is the lowest** as compared to 46 kcal/mol for PE, 55 Kcal/mole for PS and 65 Kcal/mole for PP.
- In theory, PVC is a stable molecule up to 300 deg. C.

However, the irregularities developed in PVC during polymerization like –

- Terminal and internal unsaturation giving rise to allylic chlorine (15-20 double C atoms), bonds/1000
- Branching generating tertiary chlorine (0.5-20 branches / 1000 C atoms), Unusual end groups, and
- Traces of monomers, catalyst, initiator, terminators and suspension or emulsifying agents are **responsible for thermal degradation of PVC during processing.**

Apart from thermal stability, PVC also undergoes oxidative degradation due to –

- Structural defects arise due to **incidental oxidation** during its production from drying and storing of PVC resin such as Carbon (C-O). Carboxylic (COOH), Peroxide (O-O) and Hydroperoxides (DOH) groups.

Such oxygen containing groups are called "**Chromophores**" that absorb UV radiation to get excited and breaks PVC chain on exposure to solar radiation.

- Besides, the double bonds formed during processing also undergo reaction with oxygen and generate more "Chromophores".
- **Antioxidants** are added to PVC compound, to mitigate this effect.

2. PVC procured from different sources have different thermal stability

- Due to variation in thermal stability of PVC from various suppliers, it is advisable to check thermal stability time for PVC in minutes by Congo red test or by Dehydrochlorination test as per ISO182-2 or 3
- This can help **to guide the processor** in deciding the doses of thermal stabilizer in compound.
- We can now look at the doses of thermal stabilizer **suggested by the manufacturer** and get the **first approximation** about the stabilizers.

3. Consider the residence time of compound in the extruder & extent of recycling rework

- Degradation of PVC in processing equipment follow Arrhenius equation. $\text{Log } T \text{ Sec} \propto 1/T$.
- Higher the temperature, lower is the time to degrade and vice versa.
- Let the residence time of compound in the processing equipment be **X**,
- Test the compound for the stability time in minutes by Congo red or Dehydrochlorination on tests per ISO 182-2 or 3. Say it is **Y** minutes.
- Consider whether the process waste like setting waste of trimming from calendared or T die extruded sheets is to be recycled. In this case, the residence time will be more than **X**, say **1.5 X**.

- Consider, the possibility of **power failure** and change over time to generator and vice versa. Say **Z** minutes.
- In this case, the required total stability time will be at least **1.5 X+Z** minutes. So, **Y > 1.5X + Z**.
- A processor needs to **fine tune** the stabilizer level to match this time and prepare their compound.

4. Observations

- On one side processor feels that if we follow this procedure, then the **cost will be more**.
- On the other hand, the acceleration in degradation due to blending of reworks having; less stabilizer left in it, will produce **more wastage, inferior quality and inconsistency in the product**,
- Some processors feel that instead of increasing stabilizer level in virgin compound might add stabilizer to the rework as and when required.
- However, the rework is in crushed uneven 3-4mm grains form without any porosity and absorption as well as distribution of the stabilizer **will not be uniform**.
- Some processors add ES80 to the rework that works as a multifunctional additive and help processing.

5. Suggestions

- The stability provided to PVC by stabilizers from different manufacturers is different.
- In such a situation, measuring **thermal stability of the compound and cost** is very useful.
Still better method is to compare the stability time of previously well running compound and the stability of compound with stabilizers from different supplier on '**Torque Rheometer**' and decide the dozes.

- In case of one pack stabilizer system. Torque Rheometer is very handy, not only to about the stability, but also lubricity of the compound as it compares the torque, decide
Usually, one pack stabilizer incorporates less quantity of lubricants to enable processors to add lubricants befitting their processing equipment, size of the pipe or profile, speed of extrusion and so on....

