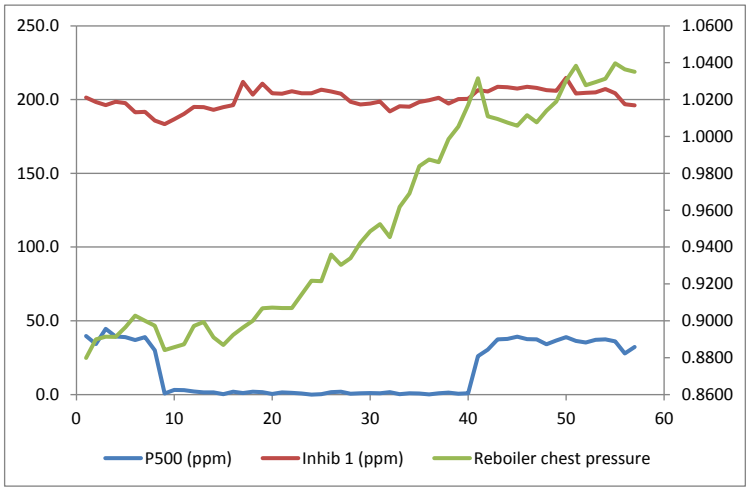
Cooling Section: Inhibitor AHM P500 to Prevent Fouling

Inhibitor AHM P500 was developed in the Nufarm R&D lab for use in higher temperature applications. It is a stable free radical inhibitor, but it is stable at higher temperatures than other Tempo molecules.

It can be used in the cooling section of a styrene production plant, between the dehydrogenation reactors and the crude SM storage. It will control fouling in the heat exchanger tubes, in the fin fan coolers and in the oil/water separator.

In addition to the high temperature stability Inhibitor AHM P500 has other useful properties;

- It is a liquid in the pure state. It does not require a solvent to be transported or pumped.
- It is physically and chemically stable between -20°C and +50°C
- It is insoluble in water. This is especially important because the water in the oil/water separator is not contaminated and can be re-used for boiler steam
- It is completely miscible with EB and styrene
- Being a stable free radical inhibitor it can give protection against DVB polymerisation and prevent insoluble cross-linked polymer from forming
  - We have plant trial evidence of the molecule performing better in the prevention of cross-linked fouling than other products



- Reboiler chest pressure increases once dosage of the trial inhibitor is stopped
- Chest pressure increase slows significantly once dosage of the trial inhibitor is re-started

Distillation Section: Nufarm DNBP as a Polymerization Retarder

DNBP (2,4-dinitro-6-sec butyl phenol) is the most commonly used polymerisation control additive in the distillation of styrene monomer. It is used similarly in divinylbenzene. Used on its own it is an effective and reliable retarder that has been proven over many years use, it can be used in all plant designs and at all temperatures found in the distillation sections.

DNBP can be used as a direct replacement for 2,4-dinitrophenol (DNP), 2,4-dinitro-o-cresol (DNOC) and 2,4-dinitro-p-cresol (DNPC). These other nitrophenols are solids with very low solubility in styrene or ethylbenzene requiring manual handling of the material on location. DNBP is a low melting point solid (35°C) and is very soluble in ethylbenzene enabling it to be pumped from a container to bulk store tank with no manual handling required.

- Most widely used polymer control additive in styrene production.
- A retarder that gives long lasting protection even under abnormal conditions which can occur in plant outages such as pump failure, vacuum failure etc
- Nufarm has a proprietary process that reduces residual free acid to extremely low levels

Nufarm DNBP can also be used in combination with Nufarm stable free radical products for improved performance at reduced cost (see **AHM 700 Series**)

Nufarm registered DNBP under the European REACH regulations in November 2010 and will continue to support this useful and valuable product.

Nufarm DNBP is available in several different formulations. We are always ready to evaluate new mixtures to suit specific customer plants.

H507A: DNBP technical, molten solid

H509A: 50% DNBP in Ethylbenzene

H510A: 70% DNBP in Ethylbenzene

H513A: 75% DNBP in Ethylbenzene

All Nufarm *DNBP* is produced at our own site in the UK and is quality controlled before leaving site. It is available in 200L drums, 1000L intermediate bulk containers (IBC) and in isotanks.

We aim for high quality at all times and in all areas; from production, through QC and shipping, to technical service.

Distillation Section: Nufarm AHM 700 Series Styrene Polymerization Inhibitors

The *Inhibitor* AHM 700 series are polymerization control additives specifically designed to enable the most efficient trouble free operation of styrene monomer production plants. They are a mixture of DNBP retarder with a true inhibitor that offers greatly improved anti-polymerization performance compared to other commonly used materials. The performance and economics have been proven at many plant trials and conversion rate from plant trial to full time use is 100% when the benefits have been demonstrated

- Easily handled liquid products.
- Superior polymer control, and can be used at a much lower dose, compared to conventional nitrophenolic products
- Reduced usage rate leads to superior economics and lower NOx when residues are incinerated
- Retarder and inhibitor properties in a single product so only one storage and feed system is required

Nufarm AHM 700 series comprises several different formulations designed to suit a variety of plant conditions and we can create custom formulations to suit specific customer needs.

Inhibitors are selected from our range of stable free radical (SFR) products and phenylenediamines.

The latest development from Nufarm is a liquid, solvent-free, mixture that reduces shipping costs and the amount of product handling required.

Inhibitor AHM 700 series are available in 1000L intermediate bulk containers (IBCs) and in isotanks.

Case History: Savings on plant >$500,000 per year

Parameter	**Pre-Trial**	**With AHM700**	**% Change**
DNBP in EB splitter, ppm	1250	900	-28
Polymer in EB splitter, ppm	3000	750	-75
DNBP in SM column, %	1.5	1.0	-33
Polymer in SM column, %	6.5	3.5	-46

Distillation Section: Green Retarders for Styrene Production

Retarder MB-1 is a Nufarm patented formulation for use in styrene in combination with a true inhibitor.

Retarder MB-1 is not classified as toxic and offers a greener alternative to the retarder DNBP.

The combination of *Retarder MB-1* and a true inhibitor provides excellent control of polymer during styrene distillation and is successfully used in several commercial styrene distillation units.

- Effective at temperatures up to 120°C
- *Retarder MB-1* is not classified as toxic
- Reduced NOx when distillation tars are burnt.
- Easy to handle liquid product

Retarder MB-1 is supplied as a 55% solution in ethylbenzene as standard but other solvents and solution strengths are possible. Please enquire.

Retarder S440 is a commercialized product in use in a number of styrene units and is based on quinone methide technology.

Retarder S440 is supplied as a 40% solution in ethylbenezene solution but is not classified as toxic. Used in combination with a true inhibitor it offers good performance.

The product does not contain nitrogen and will therefore not release NOx when the plant tars are burnt as fuel.

Retarder S450 is a patented new retarder suitable for use in all styrene monomer plants. It has been tested and shown to be effective up to 140°C and is therefore ideal for plants operating at higher operating temperatures and those operating with heat recovery systems.

The development of this product was partially supported by the European Regional Development Fund.

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For all our Green Retarder technologies, Nufarm's experienced and skilled Technical Service Team will be on hand to guide you through all aspects of a plant trial/introduction.