Formulation Guidance for the use of FP-460 in Coatings
FP-Pigments Advanced Opacifying Technology products are carefully engineered to enable the partial replacement of Titanium Dioxide in coatings, plastics, inks and paper. Their unique composition enhances the performance of the TiO₂ in the coating creating the potential for significant formulation cost savings.

In order to obtain the maximum benefit from the use of FP-Pigments we recommend that you implement the following formulation guidelines.

**Testing Protocol**

Where possible, it is recommended that you conduct your initial evaluations in a white, matt, interior emulsion paint.

Start by producing a replacement ladder, replace 5, 10, 15 and 20% of the TiO₂ with the same weight of FP-460. Please do not attempt to replace any fillers or extenders with FP-460 as this will reduce the effective performance.

If a 20% replacement is successful then continue in 5% increments up to 30%. (Note: replacement ratios above 30% may also be possible in certain formulation types, e.g. primers and undercoats)

Reformulation by weight rather than volume means that the PVC may increase slightly (typically 0.5 - 1.5 units). If necessary this can be readjusted at a later stage.

**Example of Ladder Approach for Obtaining the Ideal Replacement Ratio**

![Graph showing reflectance values over black for a replacement ratio ladder.](image)
Dispersion

It is very important to ensure that FP-460 is well dispersed in the grind. Poor dispersion reduces the efficiency of FP-460 as a TiO₂ replacement and may also adversely affect other properties of the paint. To achieve a good dispersion in the grind we recommend:

The grind pH should be above pH 9.5 at the point of addition of FP-460. We suggest pH control in the grind using a solution of 10% NaOH. Ammonia solution (typically 28%), KOH (10%) and AMP 90/95 are also suitable.

NB: Some biocides can be adversely affected by pH levels above 9.0, if this is the case then the biocide should be added at the end of the grind when the pH has reduced to below 9.0. The reduction in pH to below 9.0 should occur anyway once TiO₂ pigment is added. Please refer to your biocide supplier for further information on pH sensitivity.

We have found that the order of addition of the pigments and fillers can make a difference to the performance of the coating. The recommended order, to ensure the optimum performance of the FP-460, is to add the FP-460 first and allow it to wet out for 2-3 minutes. Once the FP-460 has fully wetted add the TiO₂ followed finally by the extenders/fillers. Where talc is being used in the formulation, it is best to add this as the very last component to the grind. We recognise that some plant configurations mean that this sequence is not possible, in which case the addition order should place the FP-460 as close to the TiO₂ addition as possible.

High shear in the grind helps optimise dispersion: stirrer tip speed should be 18–25 m/s and solids in the grind between 65 and 75%.

If dispersion issues persist then:

- use of Calgon may also help. Add it just prior to FP-460: a typical dose is 0.3% of a 30% solution on the total weight of the paint.

- increasing the dispersant level by approximately 10% over the normal dispersant dose can also assist with dispersion.

NB: Where FP-Pigments are used in combination with talc it may be necessary to increase the dispersant dose or introduce a dispersant that is effective with talc. We have found Orotan 1124 (DOW) to be particularly effective.
Guidance on the use of FP-460 in water based systems

**Role of pH in Dispersing**

As mentioned above, in order for FP-460 to work properly it has to be well dispersed. To ensure this the surface charge of the FP-460 particles must be uniformly negative. The easiest way to achieve this is by maintaining a pH greater than 9.5 at the point of addition of FP-460.

If the grind pH is less than 9.0 at point of FP-460 addition there is a chance that it will not wet-out and disperse correctly. This is a result of the presence of both positive & negative surface charges, which will attract each other, resulting in agglomerates. Once agglomerates form the efficiency of FP-460 is greatly reduced.

Once FP-460 is dispersed, add the TiO₂ & finally the extender. The TiO₂ addition tends to decrease pH and as a result some positive charge develops on the surface of FP-460. The TiO₂ particles are attracted by the positive surface charge and become attached to the surface of the dispersed FP-460 particles; this ensures that both the TiO₂ and also the extenders are well distributed.

This distributed network of FP-460, TiO₂ and extenders is relatively stable and is able to tolerate the subsequent decrease in pH that typically occurs during the course of paint manufacture. It is important however to avoid pH shock as this could flocculate both the FP-460 and the TiO₂. If a pH shock is likely, e.g. from the addition of a low pH binder (pH between 4.0 and 6.0), we recommend buffering against it by pre-adjusting the additive pH prior to adding to the millbase.

![Image showing the role of pH in dispersing](image-url)
Guidance on the use of FP-460 in water based systems

Measuring Results

We recommend that you measure the hiding power using films cast at 60μm and 120/150μm wet film thickness. By plotting the replacement ratio (10, 20, 30% etc) against the opacity values, the optimum replacement ratio can be obtained.

Once you are happy with the replacement ratio, measure other values (gloss, tint strength etc) critical for your application to determine if a lower replacement ratio is necessary.

Higher Gloss Levels

As mentioned above we recommend that initial evaluations are done in white, matt interior emulsion paint; This will allow you to gain experience with the product. When looking at satin & higher gloss systems the following should be noted:

1) Replacement levels are often (but not always) lower – around 15% as typical. At higher replacement levels there can be a significant reduction in gloss.

2) The requirement for optimum dispersion in the grind is key. Poor dispersion will exaggerate any decrease in gloss.

3) Dispersant choice & dose are important. Each paint formulation will be different however to date we have had good experience with dispersants such as Dispex N-40 (or similar products), BYK 152 and Orotan 731.

NB: Further advice on formulating with FP-Pigments in the pvc range 20 to 45% is given later in this

Formulation Fine-Tuning

Adjustments to the extender package present in the paint can be made to compensate for any changes in gloss, but this should only be done after the optimum TiO₂ replacement level has been determined.

Similarly other properties such as “re-coat” & the rheology profile (flow & levelling) can be optimised at this point. As with gloss, much of this can be achieved through minor adjustments to the extender package (balance of coarse vs fine extenders as well as the overall extender content).
**Tinting Strength**

It is important to check tint strength as there may be slight changes when using FP-460: these will become more apparent at higher replacement levels.

For “Point of Sale” tint bases we recommend producing a replacement ladder beginning at 4% and increasing to 12.0% in 2.0% increments. In most formulations we see a typical replacement ratio of between 8% and 10%, whilst maintaining both tinting strength and undertone.

For factory produced colours, higher TiO₂ replacement levels can still be achieved, typically 15 to 25%. This is because the colorant levels can also be adjusted in the factory to compensate for the change in colour strength. The results, therefore, is not only a saving in TiO₂ but also a saving in colorant. Typically, a 4 to 12% reduction in colorant can be achieved.

In a few formulations it may not be possible to match the tint strength of the standard at a high replacement ratio in these cases it will be necessary to balance replacement ratio, cost savings & desired tint strength. We have generated results with a range of tinting pastes. None of those tested preclude the use of FP-460.

Please note that replacement levels above 15% can lead to a slight increase in yellow undertone. This is due to the larger particle size of FP-Pigment compared to TiO₂. Again, this will be dependent upon the formulation and in particular the undertone of the TiO₂ being used.

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**Typical Undertone Results for a Grey Tinted Matt Paint**

Results

![Undertone with FP-460 Present](chart.png)

Similar undertone at 5% replacement then showing a slightly browner tone as the replacement ratio increases. This is consistent with adding a larger sized scattering particles to the paint.
Guidance on the use of FP-460 in PVC 20 to 45 Paints

**Mid-Sheen Paints**

For water based paints within a PVC range of 20 to 45% it may be necessary to follow a slightly modified reformulation protocol. Both the protocol and the rationale for it are outlined below:

**Testing Protocol**

1) Replace 10% of the TiO₂ with the same weight of FP-460
2) Remove 10% of the largest particle size extender/filler in the formulation

This will result in a slight reduction in the PVC of the paint which helps to maintain the gloss level of the reformulated paint. At this stage the opacity of the formulation should be checked and if necessary a small level of opaque polymer (typically between 0.5% and 1.0% on total formulation weight) should be added. If opaque polymer cannot be used, then a small percentage of TiO₂ should be added back to the formulation.

If the replacement is successful following the 10% protocol, then further reductions can be attempted and we recommend doing this in 2.5% increments.

**E.g.**

1) Replace 12.5% of the TiO₂ with the same weight of FP-460
2) Remove 10% of the largest particle size extender/filler in the formulation
3) Adjust opacity using small additions of opaque polymer or replacing some TiO₂

**Explanation:**

In paints with a PVC in the 20 to 45% range and/or relatively low pigment levels, the TiO₂ can be very well distributed (though possibly still flocced and crowded) through the film. As FP-460 has a larger particle size than TiO₂, adding it to such paints can result in an increase in crowding of the pigments and thus reduce the performance of the pigment. In order to obtain the optimum performance from the TiO₂ and the FP-460 pigment, we need to increase the volume in which the materials are dispersed and we do this by reducing the level of extender. Reducing the level of extender (and effectively reducing the PVC) will also help maintain the gloss following the addition of FP-460.

Another effect of the reduced PVC can be a small reduction in opacity. To compensate for this either add a small dose of opaque polymer - typically 0.6%, or adding back a fraction of the TiO₂ removed.