Effect of a Change of Catalyst on Fouling Performance Summary Report

Source Documents –
Independent Testing of the Antifoul performance of Aquasign™ - Scientific Services Ltd
Independent Testing of Antifouling Performance of Aquasign- CSMA Consultants Limited

Outline & Scope

A review of the test work perform on the independent raft inspections conducted between May 2000 and September 2006 was initiated to test the hypothesis that

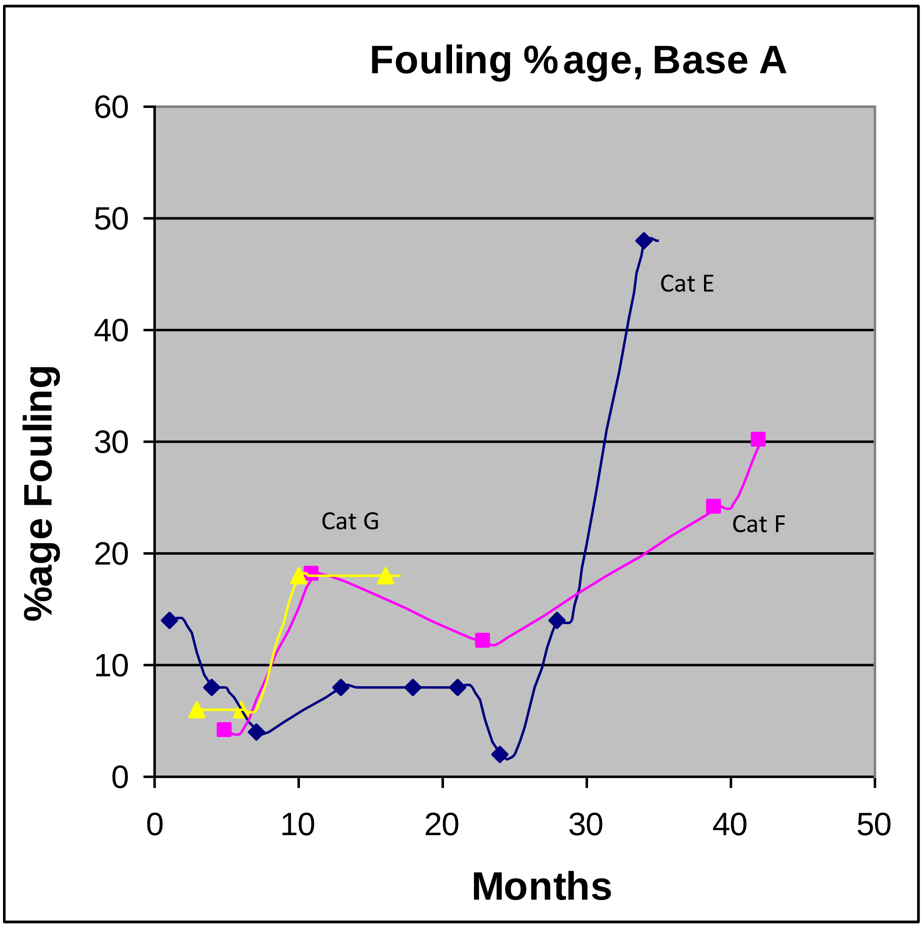
"The use of different catalysts does not alter the antifouling properties because the catalyst is chemically combined in the curing reaction into cured silicone rubber, unlike pigments which are an additive mixed into silicone rubber and not involved in the curing reaction."

Traditionally any change proposed to a formulation of Aquasign® required a full range of tests. This hypothesis needs to be confirmed and as data already existed then this would save considerable time. The catalyst is a key component so further testing would be commissioned if the result was not clear from the review.

Historically we believed that the catalyst could influence results as

- RTV 2 silicones are micro-porous and therefore will leach over time.
- Condensation cured catalysts contain a very small amount of tin. Toxicity tests suggest that this leaches out over time.
- Condensation cured rubbers can be prone to reversion, see appendix
- Catalysts often contain fillers, usually inert, or dyes and these may leach out over time

Base A



Observations

The data maps relatively closely in the early stages of the test and it is only following prolonged exposure that the data sets begin to diverge.

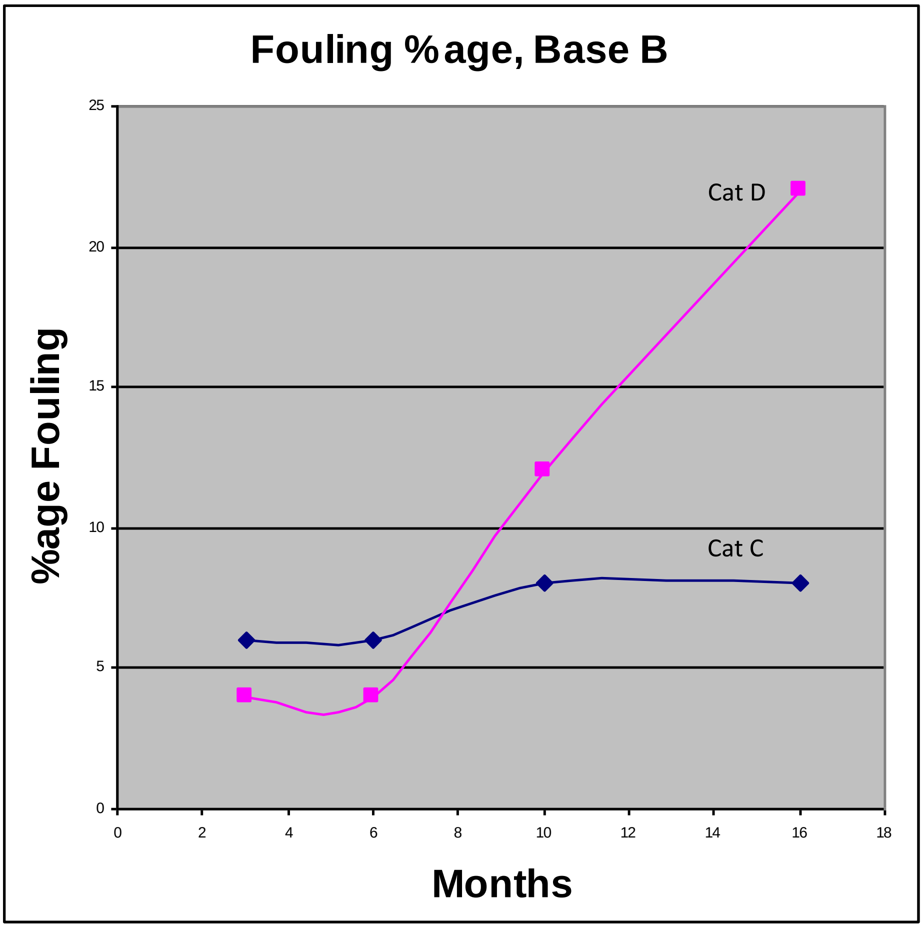
Cat E is the worst performer although a longer test period is required to determine if seasonality had a significant impact on the final test. Formulation failed.

Cat F is showing a poor trend – Formulation Failed.

Cat G is too short in test cycle to determine viability. Likely Formulation Fail.

The change to catalyst would appear to significantly change formulation performance.

Base B



Observations

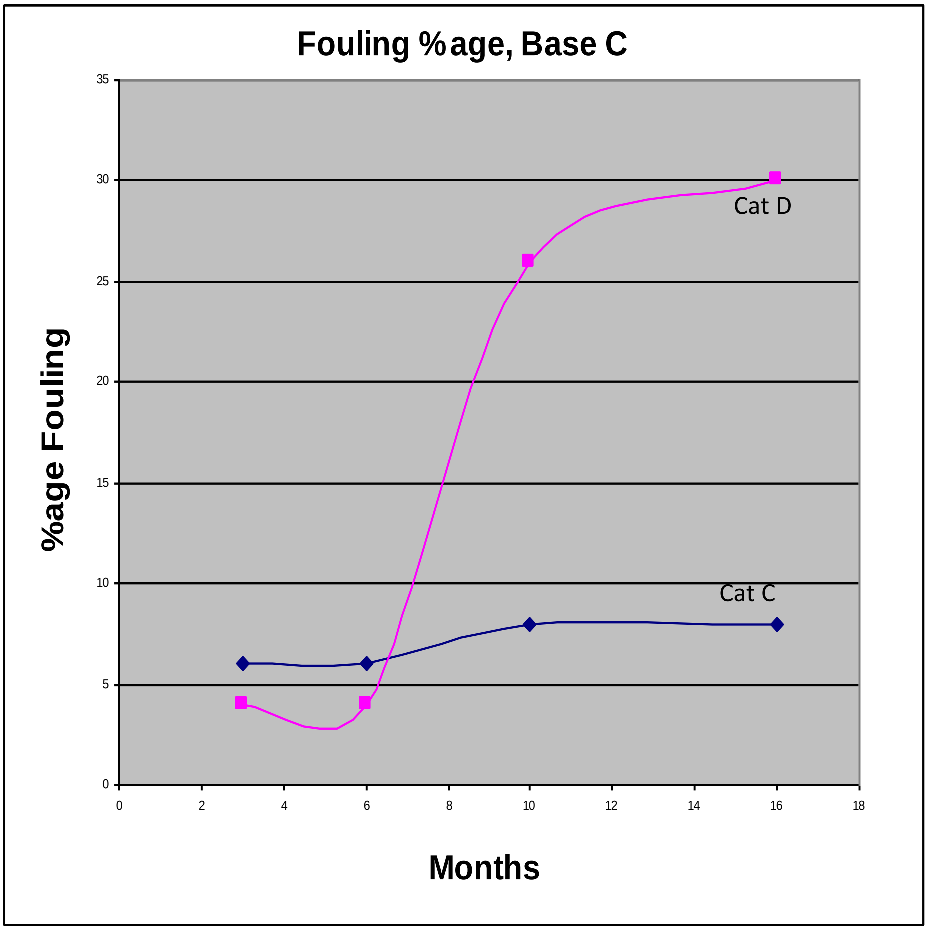
Once again the samples follow a similar performance in the early stages of the tests but following 10 months the data diverges.

Of note are the results after 16 months which showed that the amount of fouling on the samples produced using catalyst D was nearly three times that on the samples produced using catalyst C. Definite Fail.

Cat C – viable formulation for future testing

The change to catalyst would appear to significantly change formulation performance.

Base C



Observations

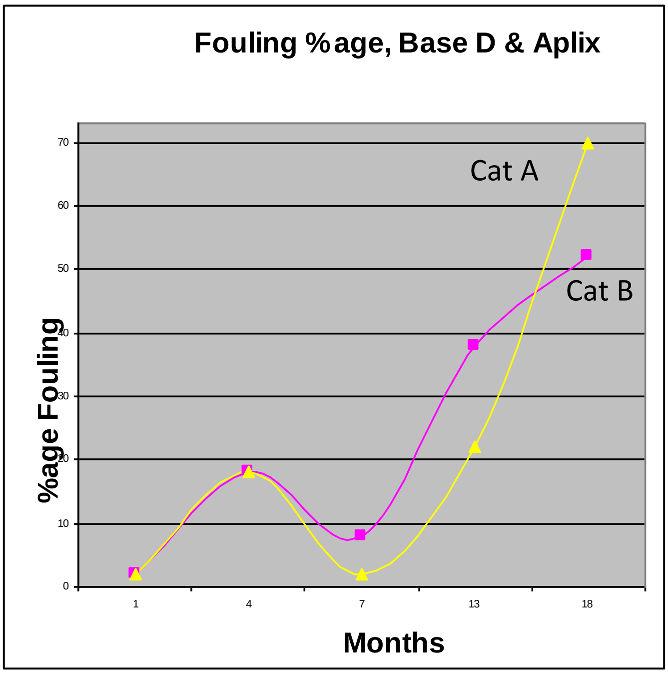
Once again the samples follow a similar performance in the early stages of the tests but following 10 months the data diverges.

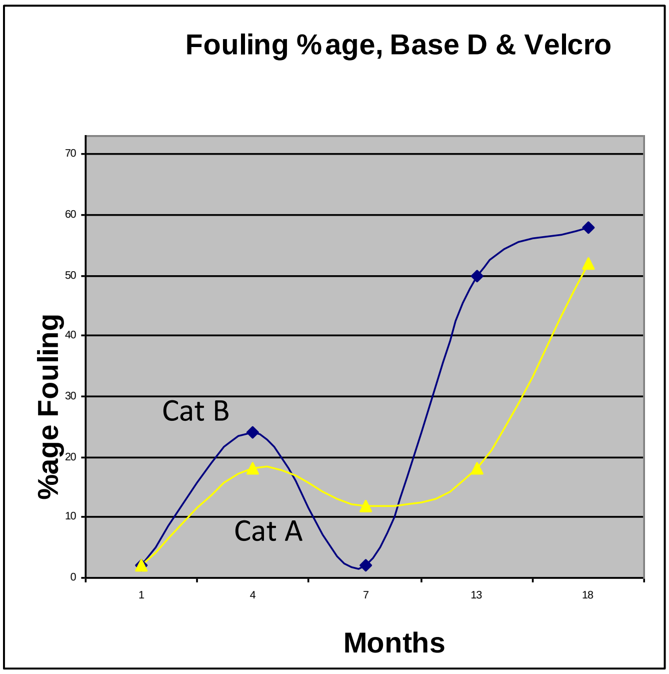
Of note are the results after 16 months which showed that the amount of fouling on the samples produced using catalyst D was nearly three times that on the samples produced using catalyst C. Definite Fail.

Cat C – viable formulation for future testing

The change to catalyst would appear to significantly change formulation performance.

Base D





Observations

All formulations failed.

The change of catalyst does not appear to change the formulations performance. It is within scientific error.

Conclusions

The data indicates that, all other things being equal, the choice of catalyst has an effect on anti-fouling performance, and that this effect ranges from small to very significant.

It is recommended when a catalyst is changed that the full range of tests is carried out.

Appendix 1

Tin catalysts & Reversion

In condensation cured rubbers, the catalysts are usually tin-based molecules. These molecules interact with certain parts of the silicone polymer chains and cause them to become ‘reactive’; they can then react with and join other chains in the blend. This joining may happen when the end of one chain joins the end of another (this is known as ‘chain extension’), or could happen when the end of one chain joins the middle of another (this is known as ‘cross-linking’). Following the joining of each pair of chains, the catalyst molecule is ‘released’ and becomes free so that it is then available to be used in a further interaction with another chain; it is not directly reacted into the chain itself.

The net consequence of these interactions is that the unconnected chains become joined together and build into a ‘matrix’ in which the chains can no longer move independently of one another; the outward result of this is that the liquid rubber turns to a solid – this is known as ‘curing’ the rubber.

Because the catalyst is not chemically joined into the chains, at the end of the reaction (i.e. once all the chains have joined together and no free chains are left), the catalyst is still ‘free’ and present in the final rubber. This catalyst remnant can cause long-term stability problems, as it can give rise to a phenomenon known as ‘reversion’; reversion is a tendency of the links in some tin-cured rubbers to ‘un-link’ with the result that the matrix starts to degrade and return to it’s original liquid state (in practise the final stage is somewhere between liquid and solid and is generally evidenced by the rubber softening rather than completely returning to a liquid).

This is notably different from addition cured rubbers where the catalyst (which is generally based on a platinum compound) is chemically reacted into the matrix as curing proceeds i.e. the compound interacts with the chains as in condensation cured, but forms part of the chain rather than being released to form . Thus there is no ‘free’ catalyst remaining in the rubber following full cure (reversion is not a problem with addition cured rubbers).