Stadis® FAQ 03-01

Product Group 03 – Fuel Conductivity Improvers

Stadis® 450 and Stadis® 425
Frequently Asked Questions

Many times each year our technical market support and customer service teams receive questions from customers on how to achieve the best performance and results from our additives or how to overcome operational problems.

There are many factors that can affect the conductivity of a fuel or its response to treatment with Stadis® additives. In this Product Bulletin we would like to share with you the most 'Frequently Asked Questions' about our Stadis® conductivity improvers for fuels.

The answers shown in this bulletin are intended to help identify the typical causes of the problems which prompted these questions and to suggest some initial responses and solutions based on our experience.

Technical service requests for Stadis® products are always given high priority by Octel's technical market support teams who are available to provide more detailed advice and information to customers on how to overcome problems with fuel conductivity.

In many fuel specifications you will see reference to 'Static Dissipator Additives' or 'SDA', these are alternative names for fuel conductivity improvers. Stadis® is the most widely approved and most highly respected static dissipator additive for fuels. Stadis® 450 is the only fuel conductivity improver / static dissipator additive internationally approved for use in aviation turbine fuels.

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Under what conditions is low conductivity a concern ?

Low conductivity is a concern under any conditions where there is the potential to generate a significant electrostatic charge during transfer or movement of hydrocarbon products, especially where a flammable environment may exist in the vessel being filled or agitated.
When a significant electrostatic charge is generated and entrained in low conductivity hydrocarbons, the entrained charge cannot quickly flow away through the low conductivity fuel to ground (earth) and so it accumulates in the vessel. Liquid hydrocarbons having a conductivity value less than 3 pS/m (3 Conductivity Units) are especially prone to accumulation of electrostatic charge.

Rapid flow rates and fine filtration of a low conductivity fuel will encourage electrostatic charges to build up. Experience shows electrostatic charging is highly variable, and it is not practical to fully eliminate it. Fires with electrostatic origins have occurred with very low conductivity fuels under flow conditions which are otherwise generally regarded as satisfactory.

Switch loading, where a tank containing a flammable gasoline vapour is then filled with a middle distillate fuel such as jet fuel, gas oil or diesel fuel, is especially dangerous if the distillate fuel has low conductivity and becomes highly charged.

Unbonded (not earthed) conductive objects will accumulate static charge when exposed to charged fuel. These objects can more readily cause a static discharge than the hydrocarbon fuel itself, hence increasing the risk. Almost any foreign body, including ice, can act as a charge accumulator.

Which fuels require Stadis® ?

The use of Stadis® 450 is mandatory in the main aviation turbine fuel specifications, primarily: US MIL-DTL-83133, UK DEF STAN 91-91, NATO F-35 and Joint Systems Check List or AFQRJOS. It may be either optional or mandatory in other aviation turbine fuel specifications.

Middle distillate ground fuels may also require the use of a Stadis® product, owing to their low basefuel conductivity at the temperature of handling. For safety reasons it is essential to ensure an acceptable level of conductivity in diesel fuel when switch loading with gasoline is being practised, in order to reduce the risk of an ignition of the gasoline vapour during loading.
Low sulphur (< 500ppm S) and ultra low sulphur (< 50ppm S) diesel fuels are usually hydrotreated during manufacture, this process removes the natural conducting species in the fuel resulting in low conductivity. It is therefore strongly recommended that these fuels should be treated with Stadis®.

Generally, gasoline does not require a conductivity improver owing to its naturally high conductivity, which is typically increased still further when treated with performance additives. Its high vapour pressure also tends to make the vessel ullage space too rich to support combustion. Unfavourable conditions can occur (due to low temperatures for example) where the conductivity of the gasoline drops below the minimum acceptable level and, at the same time, the vapour space may become flammable. In such conditions as these the fuel should be treated with Stadis®.

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How do I decide between Stadis® 450 and Stadis® 425 ?

In jet fuel applications Stadis® 450 is the only product approved for use as fuel conductivity improver (or static dissipator additive or SDA).

In other applications, the use of Stadis® 450 or Stadis® 425 is optional, depending on local conditions and requirements. However, in a location where Stadis® 450 is already in use for jet fuel, or in circumstances where other fuels may interface with jet fuel, it is strongly advised that only Stadis® 450 is used in all applications. This will ensure that Stadis® 450 is the only conductivity additive present and will prevent any possibility of adding any unauthorized additive to the jet fuel.

How should I measure the conductivity of a fuel ?

Sampling is the critical factor in conductivity measurement.

When analysing bulk fuel in situ, the conductivity should be measured in the tank using a probe submerged in the fuel. If samples are collected for laboratory analysis, they should be taken in containers impenetrable to light. Either metal cans or earthed Teflon® bottles should be used for the sample analysis. All sample containers must be thoroughly cleaned before and after use.

There are several types of conductivity meter available :

- Handheld meters with a measuring probe (ASTM D2624)
- Permanent installations for continuous monitoring of fuel conductivity (ASTM D2624)
- Precision laboratory instruments (ASTM D4308).

Precise methods of conductivity measurement are available in ASTM D2624 and D4308.
These test methods are supplemented by **Product Bulletin 03-63 How to Use Stadis® Additives #4**.

What should I know about the reformulation of Stadis® 450 ?

During 1996, Stadis® 450 was reformulated in order to prevent the disarming of water-coalescer units in jet fuel filtration systems by insoluble sulphonate precipitates.
The modification involved changing one component from dodecylbenzenesulphonic acid (DDBSA) to dinonylnaphthylsulphonic acid (DINNSA). Whilst chemically providing the same function in Stadis® 450, the higher molecular weight of DINNSA improves the solubility of any possible sulphonate salts, so that sulphonate precipitates cannot occur.

Extensive evaluations of Conductivity improvement, Water separation by filter coalescers / separators and Compatibility with other additives and aircraft fuel systems have shown that they are essentially unchanged. Since its broad commercial introduction in early 1997, there have been no reported problems with the new formulation. The earlier product based on DDBSA is no longer available.

The recommended treat rates for the reformulated product remain the same as for the earlier version, as do the handling and storage requirements.

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What is the effect of temperature on the conductivity of fuel ?

Physical effects – the conductivity of all fuels will decrease as the temperature of the fuel decreases. This is a natural property of the fuel. As the fuel temperature falls the viscosity of the fuel increases causing the conducting species to become less mobile, resulting in lower conductivity.
This effect occurs in both additive treated and untreated fuels and is reversible
see ASTM D 2624 Appendix X2 for details.

Chemical effects – Additive treated fuels may lose conductivity during storage owing to chemical interactions with trace materials in the fuel. This effect is more likely with chemically-sweetened fuels. Hydrogen-treating of fuels tends to reduce the concentration of these trace materials. These chemical interactions and the rate of conductivity loss are both increased by elevated temperatures. This effect is not reversible.

Conductivity loss due to chemical effects will be minimized if the fuel is stored at low temperatures. Losses can be further minimized by delaying addition of the Stadis® until the fuel is cool.

What is the effect of light on the conductivity of fuel treated with Stadis® ?

Exposure to sunlight can cause rapid and permanent loss of conductivity in fuels treated with conductivity improver additives. Similar, but lesser effects can be caused by fluorescent lights and other sources of UV light. Only additive treated fuels respond to light in this way. The effect is not reversible.

Glass bottles are frequently used to collect samples for laboratory analysis but should not be used for sample storage. Fuel samples stored in sunlight in clear glass bottles can lose ~50 % conductivity within 10 minutes and as much as 80 % after 95 minutes exposure. Amber glass bottles and PTFE containers do not give significantly better protection than clear glass.

Samples should be always be collected and stored in containers which are opaque to light, especially to UV light. Thoroughly cleaned metal cans, reserved for the purpose, are preferred.

The additives themselves, Stadis® 450 and Stadis® 425 as supplied, or in dilute stock solutions (5%), do not suffer any measurable loss in performance when exposed to direct sunlight for over 30 days.

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What is the effect of refinery processes on the use of Stadis® ?

Merox sweetened jet fuels show the greatest variation in response to Stadis® treatment.

The Merox process does not necessarily remove all residual amines from the fuel. They may be absorbed by the Merox clay-filter but de-sorbed by the fuel. The presence of these amines can significantly reduce the performance of Stadis® in the fuel, hence making treat-rate selection unpredictable. Laboratory analysis to optimize the Stadis® treat rate is usually recommended. Effective maintenance or modest improvements to the Merox process usually overcome the majority of the observed conductivity issues. Experience suggests that these items could include :

- Improved clay filtration
- Improved water washing
- Dilute acid wash

Many instances of poor conductivity improver response from jet fuel have been traced to an exhausted clay-filtration tower and the ineffective removal of detrimental species.

What is the effect of refinery process additives and other fuel additives on the use of Stadis® ?

Some refinery process additives, especially filming amine corrosion inhibitors have been found to have negative effects on the conductivity improving performance of Stadis® when carried over into the finished fuel.

Pre-mixing of Stadis® with other additive concentrates is not recommended without prior testing. Stadis® 450 should not be pre-mixed with jet fuel FSII (Fuel System Icing Inhibitor) as they are not compatible at the full additive concentration. Organo-basic materials, such as strong amines, are aggressive to all Stadis® products and contact should be prevented. The storage and performance properties of any planned mixture should thoroughly investigated.

Stadis® 450 is compatible with all approved aviation turbine fuel additives at their maximum use concentrations in the finishd fuel. Enhancement or reduction in conductivity-improving performance may be observed with other additives and / or with changing fuel composition.

Trace impurities in jet fuel are a major factor affecting the conductivity of stored fuels. In the absence of such trace impurities the conductivity obtained after the addition of Stadis® 450 is retained for many months. A variety of refinery fuel additives can increase or decrease conductivity. Corrosion inhibitors have little effect on conductivity at 15-25°C, but at temperatures below 0°C conductivity reductions of 20-30% may be observed.

Stadis® 450 normally gives its most consistent performance in hydrogen treated fuels, whilst chemically sweetened fuels tend to show more variation in response. At final use concentrations in fuels, using separate addition, Stadis® 450 does not affect the performance of other additives

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What is the effect of flue-gas inerting onboard tanker vessels transporting fuels treated with Stadis® ?

For the transport of fuels in tanker ships it is common practice to 'inert' or fill the empty tank headspace with scrubbed flue gas during transportation. Some impurities in the flue gases, especially sulphur dioxide, can interact with Stadis® 450 and significantly reduce fuel conductivity. Sulphur dioxide in prolonged contact with the fuel can result in almost complete loss of conductivity.

Use of an alternative inert gas, such as nitrogen, or the removal of sulphur dioxide from the ship's flue gas will help to reduce or eliminate any loss of conductivity in fuels which have been treated with Stadis® prior to loading.

If there is no way to avoid the contamination of the fuels in transit, these impurities can be removed from the fuel by clay filtration prior to treatment with Stadis® after the vessel has discharged its cargo at final destination.

Does Stadis® 450 affect capacitance gauges in aircraft fuel tanks ?

Stadis® 450 has no detrimental effects on the performance of capacitance gauges in aircraft when fuel conductivity is within the limits specified by the relevant fuel specifications.

Can Stadis® 450 and 425 be diluted prior to use ?

Dilution of Stadis® 450 is often desirable for handling purposes, e.g. solvent loss is a lesser concern, flash point is increased and viscosity is reduced. At a dilution rate of 90% or more in kerosene, the special requirements for aromatic-solvent-resistant elastomer seals and gaskets can be relaxed.

The treat rate of Stadis® 450 is typically very low (1 to 3 mg/L) and dilution may be necessary in order to "size" many injection pumps (that is bring the injection rate within the scope of the pump). Aviation kerosene is the preferred diluent.

The conductivity improving performance of the dilute blend is unchanged relative to addition of the same concentration of neat Stadis® 450.

Blends of Stadis® 450 and aviation kerosene are fully compatible in all proportions at temperatures down to –40 °C, and will not stratify or otherwise separate once fully mixed.

Information about dilution of Stadis® 450 is available in **Product Bulletin 03-60 How to Use Stadis® Additives #1**

Stadis® 425 may be diluted for all the same reasons and in the same manner as Stadis® 450.

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What are the recommended storage procedures ?

Stadis® 450 has been stored for more than ten years with no loss of conductivity improving effectiveness. Stadis® 450 is classified as Highly Flammable and the storage location and conditions must comply with local regulations and requirements. Wherever possible the ambient storage temperature should be kept below 30°C, but the maximum acceptable temperature for continuous storage is 50°C. Shelf storage life at 50°C has not been firmly established, but proving trials indicate that 2 years storage at 50°C would have no harmful effects on performance provided the drums are kept tightly closed.

Stainless steel tanks are preferred and recommended. Stadis® products may be stored in mild steel tanks provided the product is kept free of water at all times.

Elastomeric gasket and seal materials must be resistant to aromatic solvents (toluene) DuPont Viton® and Teflon® are recommended.

The low viscosity of Stadis® products enables ease of handling at low temperatures. The additives may be diluted with suitable solvents if required.

Is Stadis® suitable for use in pipelines ?

In carefully monitored pipeline tests, Stadis® 450 showed no appreciable adsorption–desorption during pipeline transfer. Other experience suggests that movement of fuels through a multiproduct pipeline can sometimes result in absorption of Stadis® 450 onto pipeline surfaces. In pipelines dedicated to a single product containing Stadis® such as jet fuel, absorption equilibrium of the surface is reached and conductivity in and out of the pipeline stabilizes. In multiproduct pipelines there is the potential for absorption of Stadis® 450 onto the pipeline surface, perhaps up to 0.3 mg/L from the initial treat rate. The extent of this absorption depends on many factors, including :

- the condition of the pipeline surface, especially the thickness of oxides which can absorb polar species from thr fuel.
- the aromaticity, or solvency of the fuel, which affects partitioning of polar species between the fuel and the surface of the pipeline.
- presence of other polar materials, such as corrosion inhibitors, which can compete with Stadis® 450 for the surface.

In general, it is preferable to use Stadis® 450 with its aviation fuel approval, in any other fuels requiring conductivity improver which might precede jet fuel through a multiproduct pipeline.

If the pipeline is not dedicated to jet fuel movements, then measures should be taken to ensure that no contaminants from previous tenders of fuel remain in the pipeline which might interact with the Stadis® in subsequent tenders.

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What is the effect of Stadis® on water separation (MSEP) ?

Throughout the jet fuel supply chain every effort is made to minimize water content in order to prevent fuelling problems at high altitude and low temperature. The primary function of the MSEP (ASTM D3948) and the earlier WSIM (D2550) tests is to ensure that the fuel has no harmful effects on the coalescer elements used to remove water from the fuel.

Studies carried out in 1996 in conjunction with the reformulation of Stadis® 450 confirmed that there is no harmful effect from Stadis® to interfere with the correct functioning of coalescers.

Although Stadis® 450 does cause some reduction in the Microseparometer (MSEP) and Water Separation Index Modified (WSIM) ratings for a treated fuel, this reduction does not result in the deactivation or disarming of coalescers in the field.

It is now accepted that fuels with an MSEP greater than 85 before the addition of Stadis® 450 will not present problems in the field.

Consequently, many aviation turbine fuel specifications no longer require the measurement of the MSEP rating after re-doping with Stadis® 450 during distribution of the fuel.

Does Stadis® 450 have any effect on coalescers ?

Coalescers are designed to remove water from fuel and form part of the Filter-Coalescer assembly used to prepare jet fuel for final delivery onto the aircraft.

Coalescers are deactivated (disarmed) by the presence of strong surfactants, particularly sulphonates, in the fuel. These surfactants are absorbed or precipitate onto the coalescer elements reducing their ability to draw together the water droplets, resulting in the water passing through into the aircraft.

The development of Stadis® 450 (DINNSA) has eliminated the possibility of sulphonate precipitation on the coalescer, and it is now generally accepted that Stadis® 450 does not adversely affect coalescer performance. Modern coalescers are qualified according to API 1581 or equivalent, on jet fuel containing 3.5 mg/L Stadis® 450. This concentration exceeds the normal use level in jet fuels.