Optimal Performance of Diesel Injectors

Greenclean® DETERGENT TECHNOLOGY

Q. What is the role of the injector in the vehicle?

A. The fuel injector is one of the most complex and critical components in the diesel engine. The fuel injector is responsible for ensuring that fuel is sprayed into the combustion chamber at the correct time during the engine's cycle and in the finely atomised form essential for efficient combustion. The fuel itself is delivered to the injector by a high pressure pump.

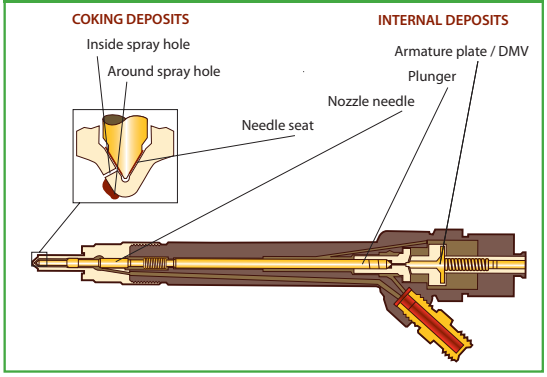
Q. Why are injector technologies changing?

A. Injector technologies are changing to meet the increased demand for reduced emissions. The most significant of these changes has accompanied the move away from indirect injection (IDI) to direct injection (DI) engines. In modern DI engines, the injection systems operate at significantly increased injection pressures and temperatures and have multiple small injector nozzle holes. As engine technologies continue to evolve, trends towards higher injector pressures will continue.

Q. How do deposits negatively impact the performance of injectors?

A. Coking deposits, also referred to as "external", "fouling" or "nozzle" deposits, can build-up in the fuel flow holes of the injector and on the tip of the injector nozzle, restricting flow and affecting spray. Coking deposits can affect emissions and engine performance. In areas transitioning to lower sulfur diesel fuels (Euro4, Euro5 and ULSD (Ultra Low Sulfur Diesel)), a second type of deposit referred to as "internal injector deposits" or "sticking deposits" has been identified. Internal deposits can form inside the injector on the needle seat, needle shaft, plunger and armature plate or DMV (diesel metering valve). As modern injectors are manufactured to extremely close tolerances, any such deposit can severely restrict movement of the internal components, leading to poor engine starting, rough engine running and excessive engine noise. *See Afton Fact Sheet "Internal Deposits and Their Impact On Diesel Fuel Injectors" for more information.*

Locations of Internal and External Deposits



Q. How is the industry measuring the impact of coking deposits on the performance of injectors?

A. There are currently two industry 'keep-clean' tests available globally: CEC-F-023 test (XUD-9) for IDI and CEC-F-098 test (DW-10) for DI, issued by the CEC and operated at its accredited test houses.

The CEC-F-023 test (XUD-9): Using the indirect injected Peugeot XUD-9 diesel engine fitted with a rotary pump injection system, this test assesses a fuels propensity to form deposits between the injector needle, pintle, injector body and needle seat, as measured by flow loss through the injector. This engine is no longer representative of the current European passenger car market, but still has significance for developing markets. The older pintle type injectors used in this engine were designed and optimised for operation with a level of coking. Such injectors initially improve in operation as they develop the level of deposits expected when they were originally designed, although excessive coking is also undesirable. For supporting information, refer to SAE 912328, where an optimum flow loss of 15-50% is identified. Additive usage should target a level of deposits within that range to ensure optimal operation of vehicles with indirect injection engine technology.

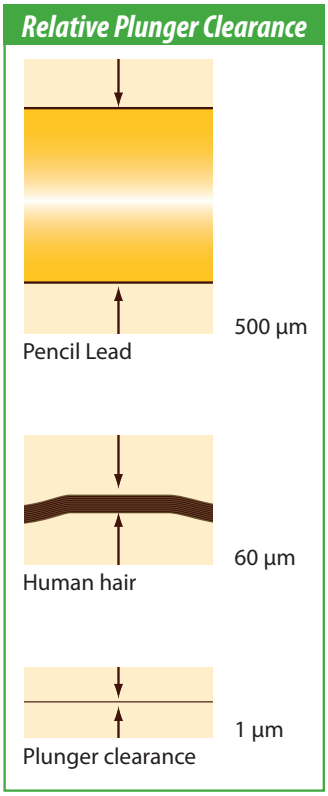
The CEC-F-098 test (DW-10): The DW-10 test demonstrates the propensity of some fuels to provoke fuel injector fouling in direct injected modern engines, and also demonstrates the ability of detergent fuel additives to prevent or control these deposits. Using the direct injected Peugeot DW-10 engine with a high pressure, common fuel rail injection

»»

Afton® CHEMICAL
Passion for Solutions™

system, this test assesses flow reducing deposits in the injector nozzle holes by measuring engine power loss. To maintain optimum performance, the injection system should remain free from deposit formation, and it is generally accepted that the maximum recommended power loss in this "keep clean" test is 2%. Currently the CEC test relies on the contamination of a non-coking base fuel with a zinc salt at 1ppm to initiate injector fouling.

Both the XUD-9 and DW-10 engine tests are designed to demonstrate that additives will protect fuel injectors from the formation of deposits. These tests are not designed to measure the ability of the additive to clean up deposits that have already formed. Therefore, use of these engine tests for "dirty-up / clean-up" demonstrations is not supported by repeatability, reproducibility, bias or other statistical methods that are necessary to prove the validity of the data.



Q. What tests are available to assess the effects of internal injector deposits?

A. There are no industry standard tests currently available to assess the effects of internal injector deposits; however the CEC is in the process of developing an engine test. Afton has also developed proprietary engine tests that can duplicate the formation of internal injector deposits found in the field today. Using these engine tests, Afton has demonstrated that its new advanced additive technology is effective in protecting injectors from these types of deposits.

Q. How does Afton's additive technology ensure the optimal performance of diesel injectors?

A. Afton has developed revolutionary deposit control additives that can prevent the build-up of deposits in the DW-10 test with both zinc contaminated and bio-containing base fuels. Furthermore, this advanced additive technology can be utilised in emerging markets with indirect injected vehicles where the penetration of direct injected vehicle technology is not fully established. Adjustment of the treat-rate can provide total fleet protection covering indirect and direct injection passenger cars and trucks.

As the market leader in diesel performance additives, Afton continuously works with engine and vehicle manufacturers, fuel injection equipment manufacturers and oil companies to develop additive solutions that deliver optimal performance to diesel injectors. Our next generation detergent technology – Greenclean® – provides the optimal protection and performance in both the XUD-9 and DW-10 engine tests. Moving beyond these tests requires a more innovative approach to performance demonstration. Afton has developed a comprehensive set of real-world data focusing on the benefits of injector deposit "clean up" in ways that will be meaningful to the consumer.

Summary

The injector system is the most complex component of the diesel engine and its technology is constantly evolving to meet performance demands (emissions reduction, fuel economy, sustained power delivery).

Ensuring injector cleanliness is a key industry concern. There are two recognised industry 'keep-clean' tests to measure the impact of coking deposits on injector performance. Optimal 'keep-clean' can be defined as >50% and <85% remaining flow in the XUD-9 and <2% power loss in the DW-10.

No industry test currently exists to show the effects of internal injector deposits on performance; however Afton has developed proprietary engine tests that duplicate the issues found in the field today.

Afton Chemical is the market leader in additive solutions for injector cleanliness and has best-in-class performance in both CEC industry tests, as well as engine tests that duplicate the internal injector deposit issue. Afton technology is also supported by the industry's most comprehensive real-world vehicle testing capabilities.

For more information please contact your local Afton representative or visit www.aftonchemical.com

The CEC tests are owned by the CEC and the full test can be purchased via www.cectests.org

Afton® CHEMICAL