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BSI Standards Publication

Liquid petroleum products — Investigation on internal diesel injector sticking deposits mechanisms and the impacts of corrosion inhibitors

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Liquid petroleum products - Investigation on internal diesel injector sticking deposits mechanisms and the impacts of corrosion inhibitors

Flüssige Mineralölerzeugnisse - Untersuchung der Mechanismen für die Bildung von Ablagerungen in Dieselinjektionsvorrichtungen und der Auswirkung von Korrosionsinhibitoren

This Technical Report was approved by CEN on 23 December 2013. It has been drawn up by the Technical Committee CEN/TC 19.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (CEN/TR 16680:2014) has been prepared by Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”, the secretariat of which is held by NEN.

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1 Scope

This Technical Report describes the investigation into diesel vehicle common rail fuel injector sticking problems in a number of countries across Europe since 2005/2006, carried out by the CEN/TC 19/WG 24/IDID Task Force. It provides conclusions following this work that have been adopted by CEN.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 590, *Automotive fuels - Diesel - Requirements and test methods*

3 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

Abbreviation	**Meaning**
AGQM	Arbeitsgemeinschaft Qualitatsmanagement Biodiesel
ACEA	Association des Constructeurs Européens d'Automobiles (European Automobile Manufacturers' Association)
BNPe	Bureau de Normalization au service des metiers du Petrole
B7	7 % (*V/V*) blend of biodiesel (FAME) with diesel fuel meeting the requirements of EN 590
B30	30 % (*V/V*) blend of biodiesel (FAME) with diesel fuel meeting the requirements of EN 590
CEC	Coordinating European Council
CEN	Comité Européen de Normalization (European Committee for Standardization)
CONCAWE	CONservation of Clean Air and Water in Europe
CRC	Coordinating Research Council
DDSA	Dodecenyls Succinic Acid
EN	European Norm
FAME	Fatty Acid Methyl Ester
FIEM	Fuel Injection Equipment Manufacturer
FTIR	Fourier Transform Infra-Red
HDSA	Hexadecenyl Succinic Acid
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-OES	Inductively Coupled Plasma Optical Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
IDID	Internal Diesel Injector Deposits
MIL	Malfunction Indicator Light
Na	Sodium
OEM	Original Equipment Manufacturer
SPMR	Societe du Pipeline Mediterranee Rhone
TRAPIL	Societe Des Transports Petroliers Par Pipeline
UFIP	Union Francaise des Industries Petrolieres

Abbreviation	**Meaning**
WDXRF	Wavelength-Dispersive X-Ray Fluorescence
WG	Working Group

4 Summary

At the CEN/TC 19/WG 24, Distillate fuels, meeting on 24 May 2011 in Krakow, Poland there were strong technical representations from the Vehicle Manufacturers (ACEA) and Fuel Injection Equipment suppliers describing serious vehicle fuel injector sticking problems in a number of countries across Europe since 2005/2006. The worst affected country was France although sporadic problems had been reported in Denmark, Germany and Spain in recent years.

As a result of these diesel vehicle common rail injector sticking field problems WG 24 recommended and CEN/TC 19 endorsed the formation of an ad hoc task force under the leadership of the WG 24 convenor to urgently investigate the injector sticking issue and provide feedback to WG 24 on a monthly basis.

5 Description of injector sticking problems

Traditional external “coking” deposits form inside and around nozzle fuel flow holes on the outside tip of injector and are caused by combustion heat and gases, interacting with diesel fuel and engine lubricant components. These deposits can affect the fuel spray pattern and volume of fuel delivered to each cylinder.

In the injector sticking case, two new types of internal injector deposits have been reported by vehicle manufacturers and FIE manufacturers, these two new types of internal injector deposits can also be found together (salt crystals inside a polymeric matrix), see Figure 1:

- Carboxylate soaps and salt deposits - typically soft, white/tan crystalline deposit;
- Organic amide deposits - lacquer, polymeric in nature, typically hard, tan/orange/brown deposit.

Deposits form on inner component surfaces of the injector restricting fuel flow by reducing armature lift and affecting injection timing and fuel volume delivery by armature and injector needle sluggishness and sticking (see also Figure 2).

Both Solenoid and Piezo actuated injectors were affected. Smaller component clearances due to increasing injection pressure and highly sophisticated injection profiles required to meet increasingly challenging emission targets make injection technologies more sensitive to IDID formation than previous generations of direct injectors.

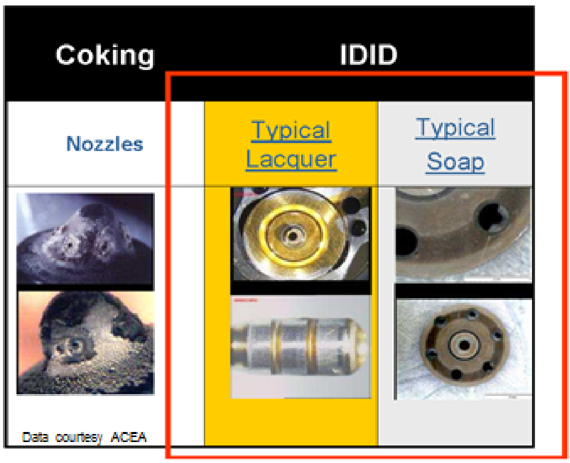
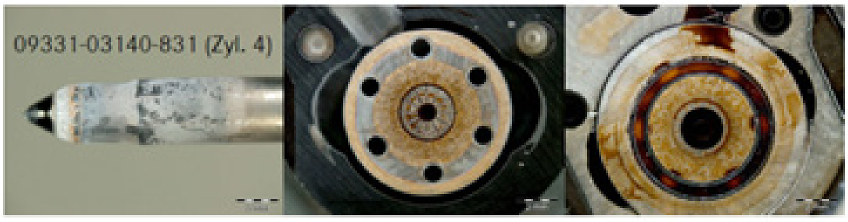


Figure 1 — Types of injector deposits (courtesy PSA)

An increased rate of injector sticking cases was reported in wintertime. Fuel Injection Equipment Manufacturers (FIEM) manufacturers believe the formation of the soaps continues all year round but that deterioration of fuel injector performance is likely to be more apparent to vehicle drivers under cold starting and operating conditions where deviations in precise control of the fuel injection becomes much a more perceptible phenomenon .

The IDID Task Force agreed to focus on the carboxylate soap deposits initially as these appeared to be the most serious and independent of the Amide deposit issue which was thought to be related to performance additive detergent (PIBSI). It should be noted however that the amide deposits contribute to the overall level of deposits increasing the likelihood of an injector malfunction or even sticking failure.



Key

injector needle (left):- aubern and white crystalline deposits

armature/solenoid (middle and right): golden brown paste like deposit

Figure 2 —Example of caboxylate injector deposits (courtesy Daimler)

6 FIEM/OEM experience

Problems with injector sticking reported in specific geographic areas:

- France was the most affected country followed by Denmark and Spain, with occasional issues in Germany.
- A higher number of injector sticking cases were reported in the northern part of France.
- The injector sticking issues in Denmark were however believed to be related to the use of a specific corrosion inhibitor additive - Dodecenyl Succinic Acid (DDSA).

Prior to 2003, no injector sticking problems had been reported in France. ACEA experts reported that all OEM's are affected to some extent and that injector sticking failures are not just restricted to Europe as most major US manufacturers of both on and off highway equipment applications with common rail systems have also reported injector sticking failures. The US failures were primarily with heavy duty engines as there are relatively few light duty diesel vehicles in the US vehicle parc. The Coordinating Research Council (CRC) Diesel Performance Committee diesel deposits panel have formed a technical group to investigate injector sticking in cooperation with the Engine Manufacturers Association (EMA).

In general vehicles covering higher mileages such as taxis and delivery vans are affected the most. Reported injector sticking symptoms include:

- loss of power and acceleration
- poor idle stability
- increased diesel knock
- misfire - especially during cold condition
- difficulty in starting particularly in cold conditions
- rough running

- Malfunction Indicator Light (MIL) illuminated in some cases

- major drivability concern and in extreme cases - no engine start

- emission deterioration and non-compliance with long-term emission requirements

Problems seem to increase with higher biodiesel content but are not always restricted to biodiesel blends. However fleets running B30 in France have not experienced any problems although this could be due to the increased solvency of the B30 from the higher level of FAME.

Problems have also occurred under high load/high rpm conditions on engine test benches but only with EN 590 diesel fuel with a biodiesel content of at least 5 % *v/v*. The first indications of similar problems under real driving conditions for passenger cars and medium/heavy duty vehicles driving more frequently at the high load/high rpm conditions occur after a mileage of 50.000 km to 100.000 km. Injectors retrieved from field vehicles show an accumulation of deposits over time exceeding a tolerable level, particularly when additional deposit material from fuel contamination or by additive compatibility issues is also taken into account.

Problems were experienced with light commercial vans in France during 2010/11 timeframe, with a regional distribution of cases (Alsace Lorraine) in western France and also cases of taxi vehicles in Denmark 2010/2011.

A large number of technical papers have been published by the industry describing research into injector sticking and references are provided in the Bibliography of this report.

7 Changes influencing internal injector deposits

A number of changes in vehicle and fuel quality requirements are believed to be responsible for internal injector deposits:

- More stringent Euro IV and V vehicle emissions standards requiring high pressure (1800 bar) fuel injection pressures and hence very small internal injector clearances, increased operating temperatures and more sophisticated injection profile;

- Sulfur free diesel with lower aromatic levels, resulting in reduced natural fuel solvency for polar compounds;

- Increased biodiesel blending up to 7 % FAME provides an additional source of sodium and weak acids (fatty acids).

8 Deposit forming mechanism

Common rail internal injector deposit analysis conducted by FIEM/OEM and fuel/additive companies confirmed the presence of carboxylate soap/salts and organic amide (see Figures 3 and 4). Figure 3 shows a typical spectrum from FTIR analysis of the deposits detected carboxylate (major peaks) and organic amide functionality on injectors returned to Ford from the French market.

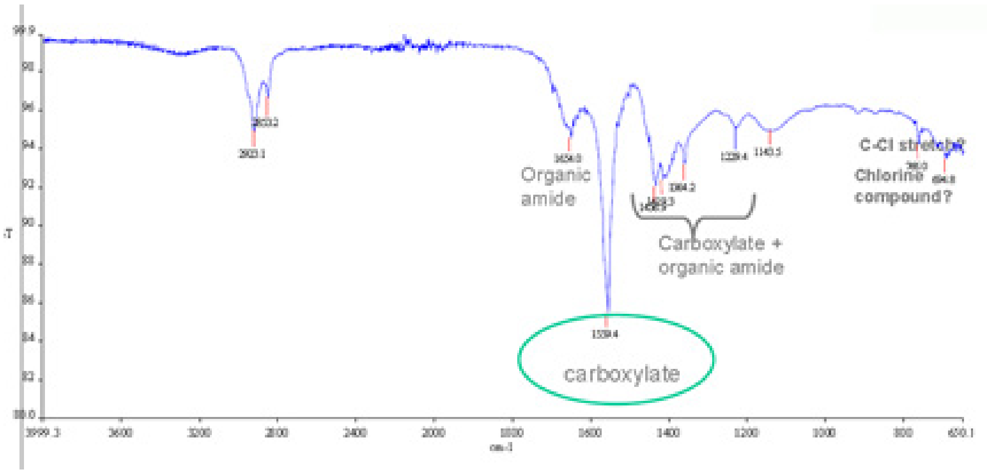


Figure 3 — FTIR analysis of injector deposits from the French market (data courtesy Ford)

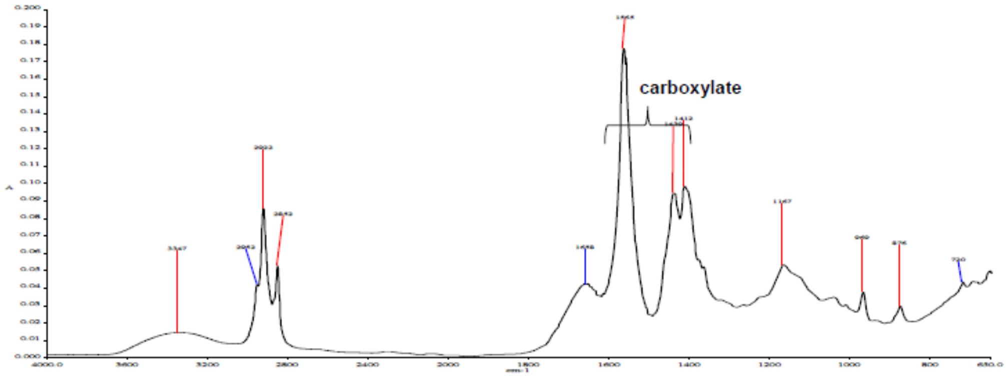


Figure 4 — FTIR analysis of injector deposits (data courtesy Afton Chemical Ltd)

There are a number of mechanisms that can result in the formation of carboxylate salts and soaps as well as organic amide deposits:

a) Carboxylates can be sodium salts of DDS acid (Dodecenyl Succinic) and HDS acid (Hexadecenyl Succinic) corrosion inhibitors.

b) Carboxylates can be sodium salts of fatty acids.

c) Carboxylates can be sodium salts of low molecular weight PIBSA/PIBSI based materials.

d) Sodium hydroxide (caustic, NaOH) can react with fatty acids in biodiesel and acidic lubricity additives to form fatty acid salts. Also corrosion inhibitors can contain sodium e.g. sodium nitrite/sodium hydroxide. Caustic is very aggressive, forming insoluble salts with biodiesel and most lubricity additives, including ester types.

It is very likely that the carboxylate sodium soap deposits are formed by a reaction between sodium in the fuel and weak acids from biodiesel and/or corrosion inhibitors.

9 Potential sources of sodium in diesel fuel

There are a number of potential sources of sodium in diesel fuel:

- refinery salt driers (sodium chloride);

- biodiesel blending (sodium hydroxide catalyst, sodium methanolate, neutralization with hydrochloric acid forming sodium chloride), although controlled by limit setting in EN 14214;
- refinery processing units (Merox desulphurisation process in the refinery with sodium hydroxide);
- refinery process additives (corrosion inhibitors);
- import terminal salt driers;
- contamination from sea water due to logistics systems (ballast water, sea water);
- airborne sodium in coastal locations (sea salt);
- pipeline corrosion inhibitors such as sodium nitrite, caustic (sodium hydroxide), soda;
- other additives - biocide?

Oil industry experience reported by Concawe experts confirms that sodium levels in diesel fuel and other distillate fuel grades reduce through the distribution system as the sodium has poor solubility in diesel fuel and migrates towards the water bottom in storage tanks and is removed via routine housekeeping tank draining.

10 Corrosion inhibitors

There are three general types of corrosion inhibitors in use:

1) Dimer acid – fuel soluble

2) Alkenyl succinic acids, such as Dodecenyl Succinic acid (DDS) and Hexadecenyl Succinic acid (HDS) – fuel soluble

3) Sodium Nitrite/sodium hydroxide – water soluble

There was some concern that alternate Dimer acid corrosion inhibitors may also form insoluble soaps although previous experience of such problems were only identified when much higher treat rates were used to enhance fuel lubricity. Dimer acids were sometimes found in deposits.

Previous issues with in-line fuel injector pump plunger sticking due to reactions between Dimer acids and engine lubricant are documented in the following SAE papers:

- SAE 2003-01-3139 [12], and
- SAE 2003-01-3140 [13].

11 Investigations in France

Discussions between UFIP/BNPe and Trapil confirmed that a sodium nitrite based corrosion inhibitor has been used in French multi-product pipelines since 1950:

- The sodium nitrite corrosion inhibitor is injected into the pipeline at a dosing rate of 4 ppm *v/v* into gasoline and diesel batches.
- There is no injection into the jet fuel.
- The additive solution consists of:
    - Summer: 22 % nitrite, 3 % sodium hydroxide and 75 % water (by volume);

- Winter (01/10 to 31/03): 23 % m of nitrite, 3 % soda, 12 % alcohol and the balance is water (by volume).

The requirement for corrosion inhibitor (CI) injection in France forms part of the pipeline owner and operators risk assessment to ensure pipeline integrity with the French authorities. The corrosion inhibitor provides low point corrosion protection where water accumulation may occur such as under the rivers, crossing roads and railways, in areas not accessible and where inspection of the pipe is not possible and the presence of water most likely. There was a high level of concern that ceasing the injection of corrosion inhibitor would lead to damaging levels of corrosion. In order to control corrosion inhibitor injection levels, measurement of sodium content in diesel after injection of the corrosion inhibitor have been made. The results were found to be below the detection limit of 0.1 ppm (m/m) indicating the test method was not sensitive enough for this purpose. The amount of corrosion inhibitor injected is minimised but with a small surplus to ensure the complete treatment of the pipeline and this would result in approximately 0,4 ppm to 0,5 ppm sodium if all the sodium is dissolved in the diesel.

Sodium contents in diesel fuel by ICP-MS were reported from two surveys conducted by SGS on behalf of ACEA and CONCAWE for the oil industry, see Figure 5 and Figure 6. The results clearly show an abnormally high level of sodium in French diesel fuel versus the rest of Europe.

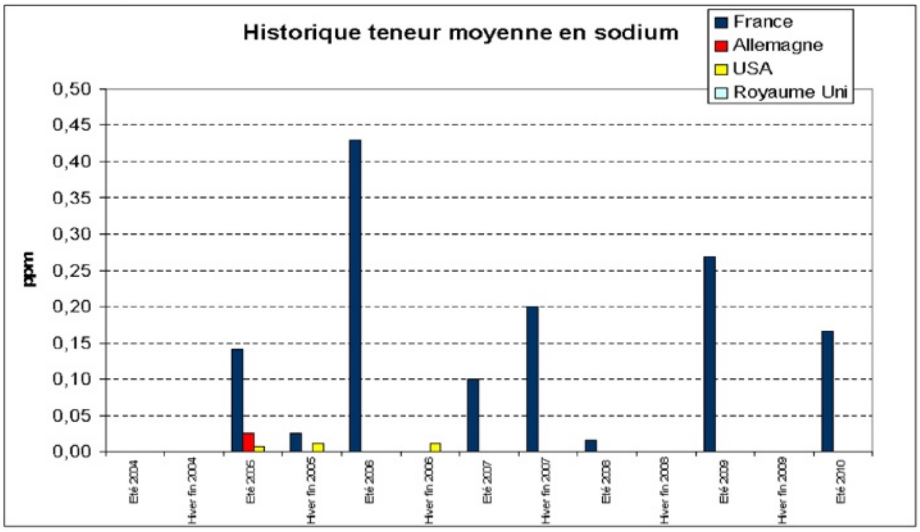


Figure 5 — Sodium levels in key European markets and the USA (Source SGS surveys)

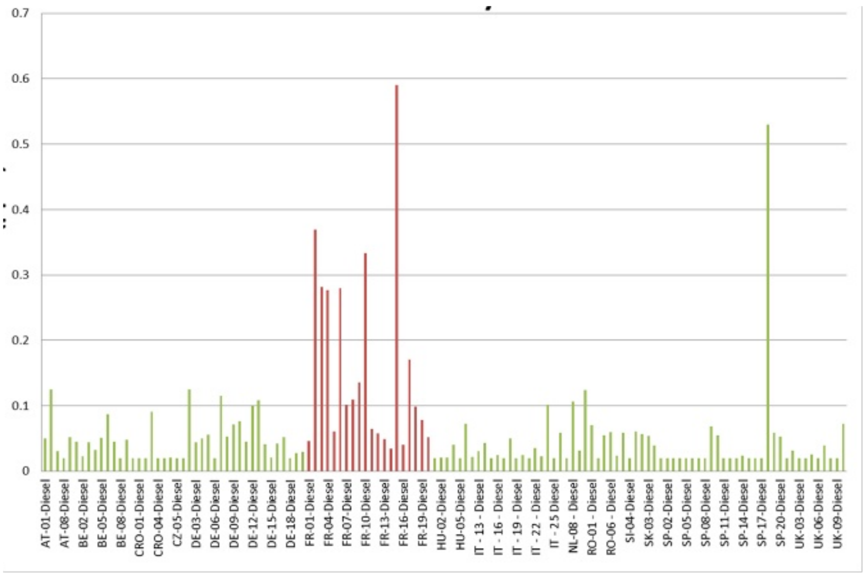


Figure 6 —European diesel survey on sodium (in mg/kg) (data courtesy CONCAWE)

Data reported by German experts (Figure 7) from an AGQM study covering the period 2000 to 2010, noted that sodium levels in German biodiesel were typically above 4 mg/kg with average levels varying between 0,2 mg/kg and 1,1 mg/kg. The European Biodiesel Board (EBB) experience indicates combined sodium (Na) + potassium (K) levels averaging around 1 mg/kg with max level of 2,7 mg/kg.

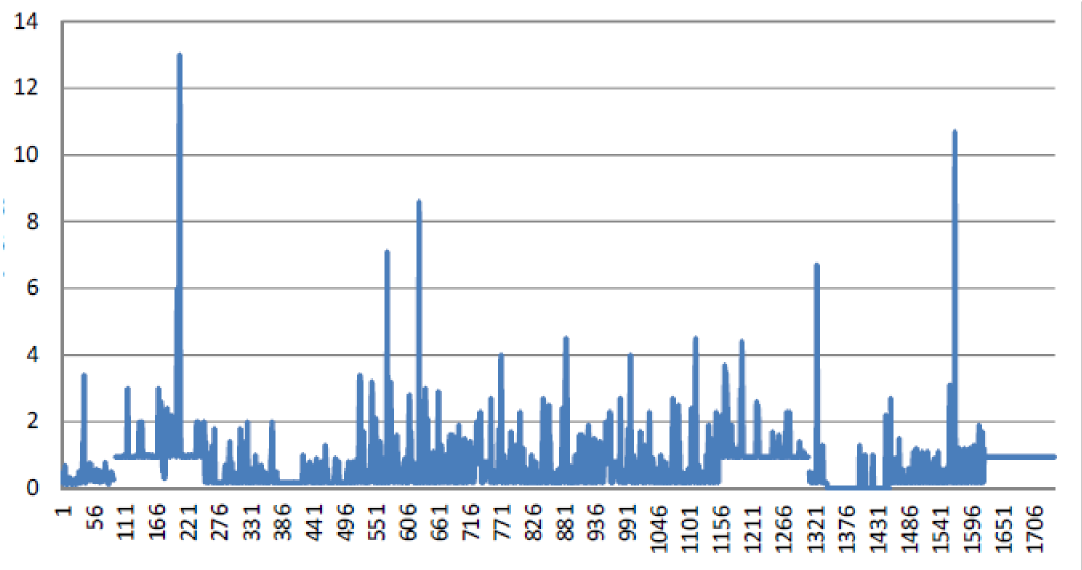


Figure 7 — Field measurements of sodium (in mg/kg) in FAME (data courtesy AGQM)

Concawe experts reported that base diesel fuel sodium contents are typically sub 50µg/kg although this can vary through the life of the salt drier in the refinery.

A level of 1 mg/kg sodium content in the biodiesel would result in diesel fuel sodium contents of around 70µg/kg and for 4 mg/kg in the biodiesel a sodium content of 280µg/kg. As previously mentioned, the sodium has poor solubility in diesel fuel and will tend to drop out with any water through the distribution system, so this probably explains the typical levels found in finished diesel fuel reported across Europe except for France where there is strong evidence that sodium nitrite corrosion inhibitor is contributing to much higher levels. Also the cases in Denmark and Spain suggest that issues with fuel handling / additivation / distribution lead to higher sodium contamination in fuels at filling stations.

Analysis of service station diesel fuel sodium contents reported by ExxonMobil in France showed a good correlation with pipeline fed terminals further supporting the theory that the sodium nitrite/caustic pipeline corrosion inhibitor was the most likely cause of the IDID sticking problems in new common-rail, high pressure fuel injectors. It seems that the corrosion inhibitor almost certainly resulted in the immediate formation of sodium carboxylate soaps in the fuel preventing the normal drop-out of sodium in the distribution system through normal housekeeping water draining from tanks.

After extensive technical discussions between CEN experts, the pipeline operators and French authorities, with the help of UFIP and BNPe, both Trapil and SPMR pipeline operators agreed to cease the use of the sodium nitrite/caustic corrosion inhibitor in French pipelines.

Evidence from Germany (RMR Pipeline) and the UK (Mainline, Midline and Esso systems) indicates that the use of corrosion inhibitor does not provide significant benefits in multi-product pipelines. Most pipeline corrosion is external and is usual due to damage from unauthorised excavation, poorly applied external corrosion protection or abrasion due to pipeline vibration and movement. There is little evidence of internal corrosion based upon analysis of removed sections of pipe work during maintenance or pipeline diversion and routine internal intelligent pigging operations where the wall thickness of the pipe is measured. Based on these findings the caustic sodium nitrite corrosion inhibitor has been removed from the French multi-product pipeline system and has not been replaced by a different one.

Initial feedback from the French market from ACEA member companies indicates a rapid fall-off of injector sticking vehicle failures since the use of the corrosion inhibitor was ceased mid-2012. CEN continues to monitor via feedback at the IDID task force and WG 24 meetings from ACEA.

12 Investigations in Spain

Repsol experts reported their experience in Spain with internal deposits in both common rail injector of light duty and heavy duty vehicles and nozzles of heating oil burners.

During years 2005-2006, some incidents were reported with light duty vehicles suffering from internal injector deposits issues (see Figure 8).

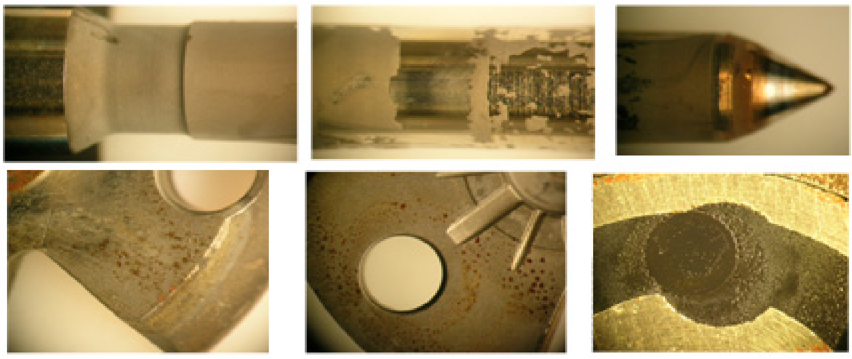


Figure 8 —Internal common-rail injector deposits from a light duty vehicle (courtesy Repsol)

In the meantime up to now, only sporadic cases have been reported, indicating that the problem may be associated with occasional confluence of multiple factors. These problems have been seen in both passenger cars and heavy duty vehicles which experienced poor engine operation, poor driveability, rough running or inability to cold start engine. The internal deposits issue was concentrated geographically in the centre of Spain.

During the winters of 2009-2010 in the centre of Spain many problems were observed related to internal deposits in nozzles from heating oil boilers (see Figure 9). These deposits caused boiler malfunctions such as, white smoke or a failure to start.

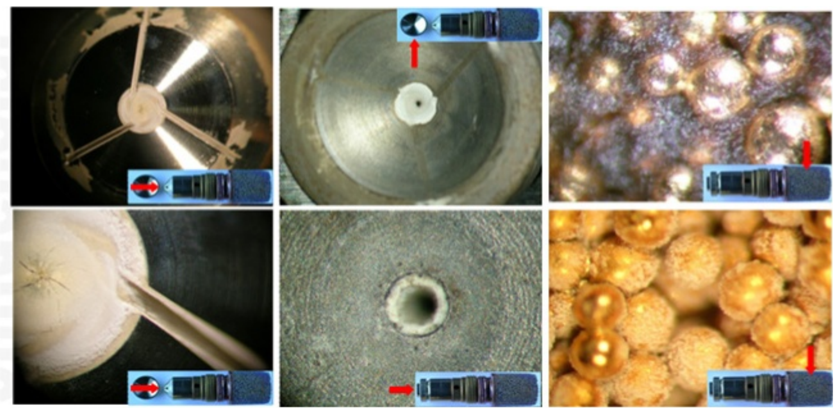


Figure 9 —Internal nozzle deposits in heating oil burners (courtesy Repsol)

Heating oil boilers are a significantly different application in comparison with automotive fuel injection nozzles, however the deposits found and analysed were similar in chemical composition in both applications. This revealed a number of interesting observations:

- different properties of fuels used, e.g. composition (no FAME was used in heating oil application, only traces from contamination in pipelines);

- quality of the automotive diesel fuel versus heating oil e.g. different sulfur content;
- different operating conditions e.g. lower temperature and pressure in heating oil boiler nozzles in comparison with common-rail injectors still allows the formation and adhesion of similar types of internal deposits to the metallic surfaces of the internal components of nozzles and injectors.

Several common rail injectors and nozzles have been analysed and for this purpose an analytical procedure was developed in order to correctly characterize the deposits. It was found (see also an example of a GC-MS analysis in Figure 10) that the main components of deposits were sodium carboxylic salts coming from isomeric mixture of C12 succinic acids and C16 (palmitic) and C18 (stearic and oleic) fatty acids. Also a minimal presence of esters and amides were detected. Sources for the acids which form carboxylic salts were investigated from oxidized fuel, FAME content or additives. Only detergent additives for diesel applications (PIBSI) and pipeline corrosion inhibitor additives were believed to be related to this issue. Different PIBSI additives were analysed in order to find succinic acids traces from its synthesis process, but evidence of them was not found. The corrosion inhibitor used during recent years in the main Spanish pipelines network was analysed resulting in the containment of isomeric C12 succinic acids and C16 and C18 fatty acids, which generated the sodium carboxylates found in the internal injector deposits. Therefore, evidence was obtained that linked corrosion inhibitor additive used in the main Spanish pipelines network to internal injector deposits formation.

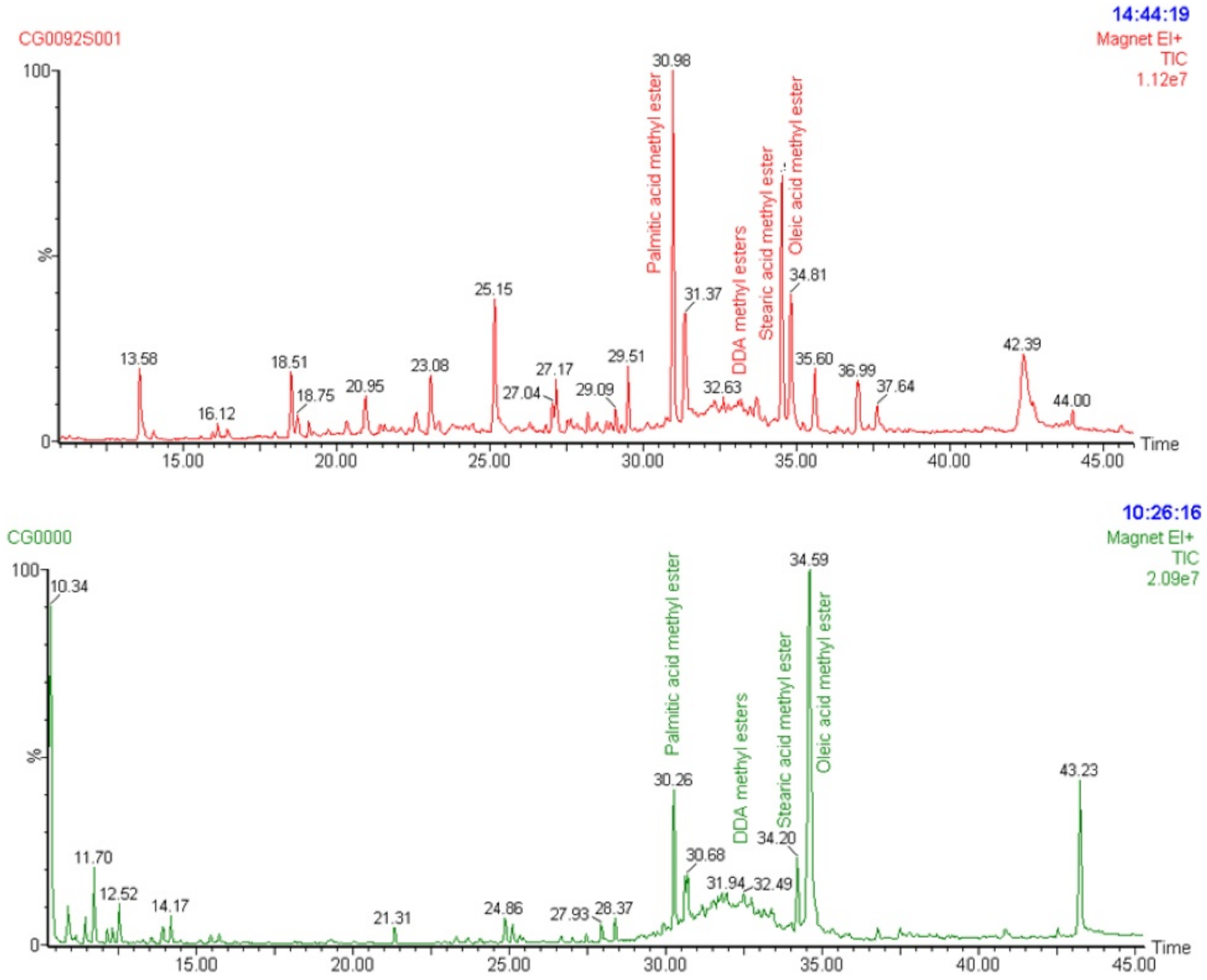


Figure 10 — GC-MS chromatograms from all deposits adhered to nozzle needle (red line) and corrosion inhibitor additive (green line) after solubilisation and derivatisation process

As a result of the discussions in the CEN IDID Task Force, the main Spanish pipelines network (CLH) undertook to investigate alternative corrosion inhibitors from that used currently (containing C_{12} succinic acids or DDSA).

After the 2010 issues, no new incidents of internal deposits in common rail injectors or nozzles have been reported in Spain.

13 Investigations in Denmark

The DDS acid corrosion inhibitor used in pipelines appeared to be the trigger for a start of the IDID problems in Denmark. The injector sticking could not be avoided by the use of diesel performance additives. Change in corrosion inhibitor technology has not eliminated the sticking issue however there has been a very significant decrease (approximately 90 %) in IDID issues in Denmark following removal of the DDSA corrosion inhibitor. A few minor problems remain, but these are mostly confined to some fleets, however, the issue is very greatly improved.

Combinations of driving cycle (taxi), injector type, sodium concentration and acid type lubricity and pipeline additives can cause injector problems

Studies conducted by Kuwait Petroleum showed that filter blocking issues could be related to the acidity of pipeline anti-corrosion additives. Components with high acid number (AN) give a higher chance of filter blocking when sodium is present. See Table 1. Note that some of the additives tested were diluted, the neat additive acid numbers are shown in parenthesis for information. Filter blocking is an indication for the formation of a deposit.

Table 1 — Acid Number of different corrosion inhibitor additives

Additive application	**Chemistry**	**Acid number** mg KOH/g
Lubricity additive	Mono acid	202
Pipeline anti-corrosion additive	Dodecenyl Succinic Acid	155 (240)
Pipeline anti-corrosion additive	Dimer acid	101 (202)
Lubricity additive	Ester	0,74

Figure 11 shows the acid number effect on filter blocking tendency in the presence of high sodium concentration (100 mg/kg Na).

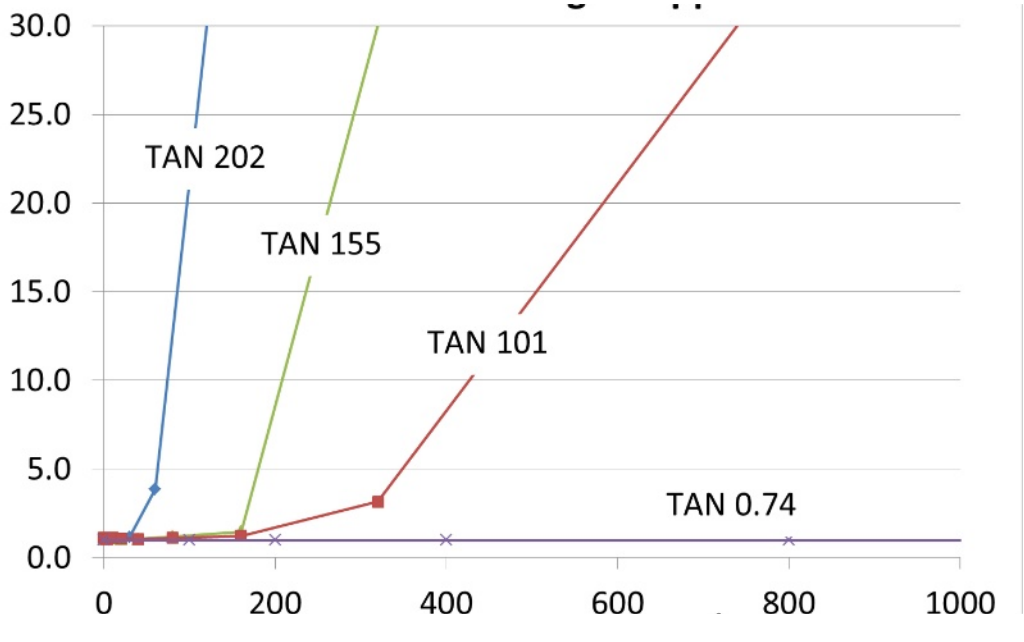


Figure 11 — Filter Blocking Tendency (FBT) vs. additive concentration (in mg/kg)

In the field high sodium concentration of 100 mg/kg are rarely present in diesel fuel so the experiments were repeated with focus on the acid type lubricity additive in combination with lower levels of sodium. It was observed that at a low sodium concentration the FBT is affected when higher concentration of acid type lubricity additive is present. See Table 2 and Figure 12 for further details.

Table 2 — FBT vs. acid lubricity additive content at different sodium contents

Diesel additive content mg/kg (TAN = 202)	**Sodium content** mg/kg						
	0	0,05	0,1	0,2	0,4	0,8	100
240	1,00	1,00	1,09	1,38	3,16	4,40	30,02
200	1,01	1,01	1,03	1,41	2,52	4,40	30,02
120	1,00	1,01	1,01	1,94	3,88	4,40	30,02
60	1,00	1,01	1,01	1,09	1,49	1,35	3,88
30	1,00	1,01	1,01	1,01	1,04	1,23	1,15
15	1,00	1,01	1,01	1,01	1,01	1,01	1,04
0	1,00	1,01	1,01	1,01	1,01	1,01	1,11

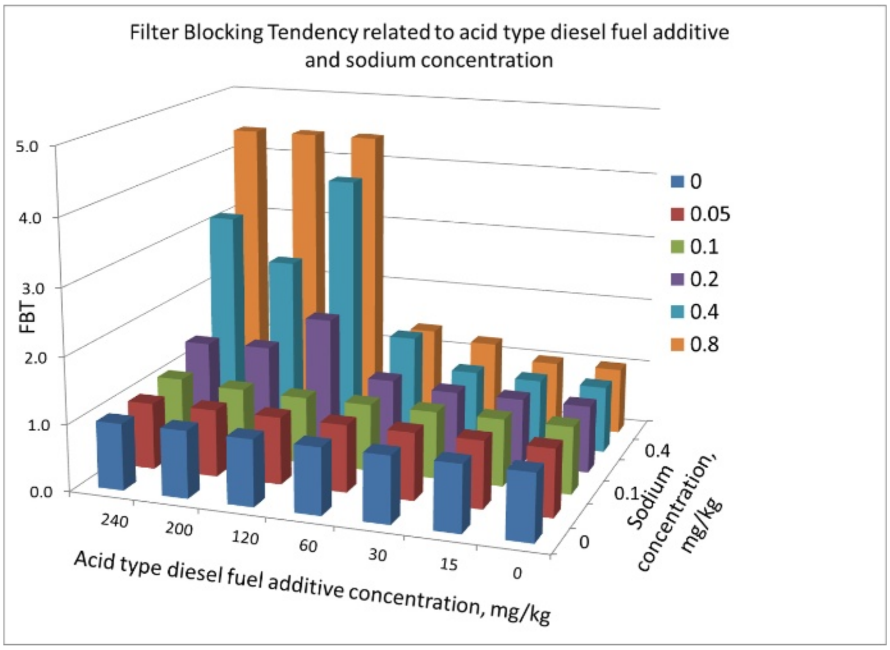


Figure 12 — FBT vs. acid lubricity additive content at different sodium contents

14 Conclusions

14.1 The root cause of the internal injector deposit problem that has resulted in vehicle failures in France, Spain and Denmark is due to different chemical interactions between fuel corrosion inhibitor additives and contaminants present in the diesel fuel from the production process. The failure mode was triggered by changes in vehicle fuel injection technology and the introduction of sulfur free fuel quality driven by more stringent legislative emission requirements.

14.2 This new failure-mode means that high pressure common rail injectors are sensitive to the formation of sodium carboxylate soap deposits that can be formed either by reaction of caustic sodium nitrite corrosion inhibitor with fuel acids/acidic lubricity additives or by the interaction of some acidic corrosion inhibitor additives with low levels of sodium found in the diesel fuel. This problem is probably aggravated by sulfur free diesel with lower aromatic levels, resulting in reduced natural fuel solvency and increased biodiesel blending up to 7 %, providing an additional source of sodium and weak acids.

14.3 There is also evidence that some fuel detergents (PIBSI based) may be contributing to additional amide deposits that contribute to the overall deposit level.

14.4 Removal of the sodium nitrite corrosion inhibitor in the French pipeline system appears to have resolved the injector sticking problems in France based upon a significant reduction in reported incidents. It is expected that sticking incidents may continue for some time as levels of deposits may have already built-up in fuel injectors prior to ceasing additive injection. It is important that (French) industry experts report back regularly on reported incidents to CEN in order for CEN/TC 19/WG 24 to monitor the market (see also Clause 15)

14.5 There is strong evidence that other corrosion inhibitors such as alkenyl succinic acids (Dodecenyl Succinic acid (DDS) and Hexadecenyl Succinic acid (HDS)) also react with sodium present in the diesel fuel to form sodium carboxylate soaps. Also Dimer acids at higher treat rates (>30 ppm *v/v*) have also been shown to cause inline fuel injector pump sticking where the pump is lubricated with engine oil and the fuel and oil come into contact on the fuel pump plunger and react to form a sticky deposit. It is therefore recommended that careful consideration and no-harm testing is conducted on potential corrosion inhibitors for use in diesel fuel to ensure the correct operation of all diesel engine fuel injection systems including filtration as required in EN 590.

14.6 CEN/TR 15367-1 [16] or CEN/TR 15367-3 [17], guides for good diesel fuel house-keeping, will need to be supplemented by further information and advice on preventing contamination by sodium that may occur in the supply chain.

15 Future work

The CEN/TC 19/WG 24/IDID Task Force has been requested to investigate into the effect of detergent additives (PBSI) on internal fuel injector deposits in order to provide guidance to the industry in the selection of appropriate detergent additives that ensure the correct operation of high pressure fuel injectors in modern vehicles.

The CEC have announced the development of a new Internal Diesel Injector Deposit test [14]. The objective is to develop a test that will discriminate between fuels that differ in their ability to produce IDID in direct injection common rail diesel engines. These deposits differ from injector nozzle coking based on the location of the deposits and on their effects on engine performance.

The proposed test engine is a current and recent variant of the DW10C– Euro 5 engine family developed by PSA Peugeot Citroën. It is known that the DW10 engine is sensitive to IDID, particularly in its calibration to meet Euro 5 emissions legislation. PSA have confirmed that this engine will be available in production for at least 10 years. PSA is a well-known supporter of a number of CEC engine tests, supplying the hardware through its engine supply company Peugeot Citroën Moteurs. It is intended that this company will be the source of the engine and hardware requirements for installing and running this candidate CEC test.

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