SLOVENSKI STANDARD
SIST-TP CEN/TR 16680:2014

01-maj-2014

Tekoči naftni proizvodi - Preiskovanje mehanizmov notranjega dizelskega vbrizgavanja zadrževalnih nanosov in vpliv korozijskega inhibitorja

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

Flüssige Mineralöl-Erzeugnisse - Untersuchung der Mechanismen der interne Diesel Injektor klebrige Deposite und der Einflüssen von Korrosionsinhibitoren

Produits pétroliers liquides - Récherche des mechanisms des deposits en injecteurs internes du gazole ét des impacts des inhibteurs corrosives

Ta slovenski standard je istoveten z: **CEN/TR 16680:2014**

ICS:

75.160.20	Tekoča goriva	Liquid fuels

SIST-TP CEN/TR 16680:2014 **en**

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 16680

February 2014

ICS 75.160.20

English Version

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.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. CEN/TR 16680:2014 E

Contents

page

Foreword 3
1 Scope 4
2 Normative references 4
3 Symbols and abbreviations 4
4 Summary 5
5 Description of injector sticking problems 5
6 FIEM/OEM experience 6
7 Changes influencing internal injector deposits 7
8 Deposit forming mechanism 7
9 Potential sources of sodium in diesel fuel 8
10 Corrosion inhibitors 9
11 Investigations in France 9
12 Investigations in Spain 12
13 Investigations in Denmark 14
14 Conclusions 15
15 Future work 16
Bibliography 17

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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.

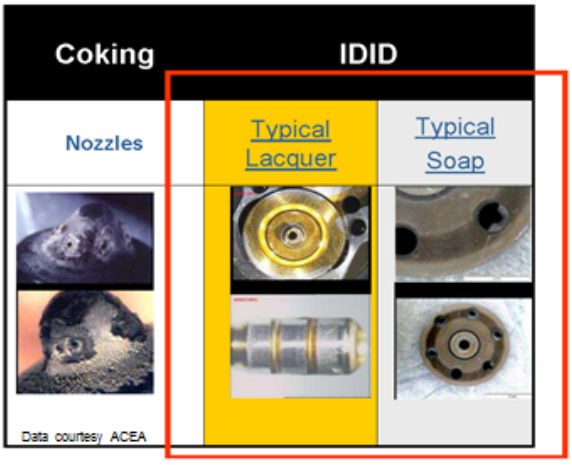

Figure 1 — Types of injector deposits (courtesy PSA)

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.