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E20/25 Technical Development Study

Task 1: Review of E20/25 parameters and test methods

Report #1

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final

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1. Introduction

Biofuels have been used in transportation for a considerable time. Brazil started its Pro-Alcohol programme in the 1970s to promote the use of ethanol as an alternative fuel for cars. Over the last three decades, the USA has developed a massive biofuels capability based on corn-derived ethanol. Now, biofuels programmes are being implemented by countries across the globe.

In December 1997, the Kyoto Protocol committing developed nations to reductions in greenhouse gas emissions, was adopted under the United Nations Framework Convention on Climate Change (UNFCCC). Kyoto, and other factors such as escalating oil price and increasing desire for sustainable transport fuels, has helped spur the global development of biofuels.

In Europe, a strategy of promoting the use of biofuels or other renewable fuels has been driven strongly by the European Commission. Under the Biofuels Directive[1] (2003/30/EC), the EU established a goal of reaching a 5.75% share of renewable energy in the transport sector by 2010. Under the Renewable Energy Directive[2] (RED, 2009/28/EC), this rose to a minimum 10% share in every Member State in 2020. The Fuel Quality Directive[3] (FQD, 2009/30/EC) required fuel suppliers to reduce GHG emissions from transport fuels by a minimum of 6% in 2020, compared to 2010. The Commission aims to ensure the use of sustainable biofuels only, which generate a net GHG saving without negative impact on biodiversity and land use. The further development of the RED and FQD continues, and this important topic is currently the subject of vigorous debate within the European institutions.

Over the last few years E5, a blend of gasoline and 5% ethanol, has become a standard grade of gasoline in many European countries. In some countries, such as France, a 10% blend (E10) has come into widespread use. Indeed, E10 is the basis for the most recent standard for unleaded petrol in Europe, EN 228:2012[4]. Much higher levels of ethanol blending exist in other parts of the world, and five countries already have specifications in place for E10+ petrol (Brazil, US, India, Paraguay and Thailand). There has been significant interest within Europe in exploring the potential for increased use of ethanol incorporation into fuel. E85 already has carved out a specific role, in parts of the EU and elsewhere, and appropriate vehicle technology is well established.

The current study tries to help move the debate around E10+ fuels forward; it focuses upon the use of bioethanol as a renewable biofuel, and does not cover biodiesel.

In 2011, a consortium of the European Commission's Joint Research Centre, EUCAR and CONCAWE reported[5] on scenarios to meet the requirements of the Renewable Energy Directive and the Fuel Quality Directive, certain of which included the introduction of higher ethanol-containing fuels such as E20. In June 2013, CEN/TC19/WG38 issued a report[6] (CEN/TR 16514) on 'E10+ fuels' with a particular focus on E20/25. E20/25 fuels are defined as those containing between 20% (E20) and 25% (E25) of ethanol, and for use in spark

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ignition engines. Now, the European Commission is proposing further work in this area to explore the feasibility of E20/25 introduction, as recent studies indicated that GHG emissions and certain other pollutants could be significantly reduced this way. Increasing ethanol content could also have other beneficial impacts such as decreasing vapour pressure and increasing octane.

As part of a new Framework Partnership Agreement between the European Commission and CEN, the Commission is funding a study project on E20/25 fuel specifications, jointly with ePURE. The aim is to provide all concerned market players with a better understanding of what an E20/25 fuel could be, the impacts on environment and energy efficiency this would have, and the hurdles which would need to be overcome. The study, which will be managed by ePURE, consists of three tasks which have been subcontracted as follows:

1. Review of the E20/25 parameters and test methods, by Davison Consultants Ltd
2. Meta-analysis of E20/25 trial reports and associated data, by the University of Vienna
3. Trial on energy and environmental performance of E20 capable cars, by IFPEN, the French research institute.

This report is part of the first task, and examines the parameters (and test methods) relating to E20/25 fuels. It aims to build upon the significant body of robust work that already has been established.

2. Aims

The aim of this first task is to consider, with participation and input from key stakeholders, how fuel specifications may look in the range E20 to E25, and to review the parameters and test methods which would be appropriate. Critical parameters for an E20/25 specification would be examined in conjunction with the European oil industry and automotive manufacturers, to establish technical and economic concerns and to consider how they could be resolved. Blend level scenarios would be established according to feedback. This would be followed by an assessment of the relevant test methods for these parameters.

The objective is to reach a consensus on possible specification(s), but it is important to emphasise that this implies no policy commitment on behalf of any stakeholder.

The WG38 report examined the technical issues associated with the introduction of E10+ fuels, with a special focus upon E20/25.The intention of the current study is to build upon that work, as a step forward in understanding. The study also will take into account developments in the work underway in the CEN/TC19/WG21 Ethanol Fuels Task Force,

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which is developing a standard for ethanol for blending at all levels up to and including 85%, and for E85 itself.

The study focus is initially on ethanol as a starting point to help point the way forward, but at some point the debate would need to consider other oxygenates, such as ETBE and butanol, in the same way that the recent revision of EN228 has done so.

3. Process

It was envisaged that the work would be undertaken by a combination of personal interviews and workshops in which invited European experts would come together to debate the major issues. Initially, two workshops were foreseen – the first to consider the parameters, and to set the stage for Tasks 2 and 3. A second workshop would then be held in 2014, after completion of the meta-analysis and car trials, to review potential specifications and test methods so that they are as robust as possible.

The timing of the first planned workshop in June 2013, however, coincided with a period in which there was active debate in the key stakeholder sectors, particularly the auto industry. ACEA is working hard to reach a consensus in Q4 2013 on an industry view of future ethanol fuel specifications, particularly around octane, blend level and range, and grade logistics. Debating these issues in a cross-industry forum during this process would have been difficult for the industry and for individual companies. Consequently, the decision was taken, in conjunction with the Project Team, to postpone the first workshop, and concentrate on developing understanding via a series of 1:1 conversations with key European experts in the oil and auto sectors.

The subsequent workshop is still planned to take place at the appropriate time in 2014.

Regarding the stakeholders involved in discussion, the focus to date has been on the auto manufacturers (ACEA and also individual OEMs), the oil industry (including CONCAWE), and ethanol manufacturers. Other possible parties to be involved include specialists in standardisation bodies such as CEN, experts in 2nd generation biofuels / advanced biofuels and the European Commission. Others under consideration are the UK Downstream Fuel Association (DFA) and the Union of European Petroleum Independents (UPEI). Equipment suppliers have not yet been approached at this stage, but associations could include the European Association of Automotive Suppliers (CLEPA, for injectors) and the Association for Emissions Control by Catalyst (AECC, for after-equipment). At the time, companies were working within their respective industry associations to agree industry-wide positions on E10+ fuels, so official positions were not available. Nevertheless, companies were generally comfortable in expressing informal views on the subject.

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Fourteen 1:1 meetings/discussions were conducted between March and July 2013. These covered five from the Auto industry, four from Oil, four from the Ethanol sector and one from related industry. All were informed that discussion was confidential and no individual or company would be named in this report. It is the intention to maintain such confidentiality for further meetings and workshops, should this be preferred by the stakeholders involved. The people interviewed covered both fuels technical specialists as well as those involved more with biofuels strategy within their organisations.

This report is based principally on the outcome of the 1:1 meetings/discussions, but also draws some relevant context from the WG38 report, and relevant European and other international specifications.

4. Key Themes

There has been a long process within CEN/TC19/WG21 to develop European standards for ethanol fuels, firstly through an Ethanol Task Force and an E85 Task Force, then from 2011 through a combined Ethanol Fuels Task Force (EFTF). The EFTF is currently charged with developing a revised standard for ethanol itself, and a new standard for E85. Parameters and test methods have been for many years the subject of much debate across the main stakeholder interests, but much progress has been made.

Before parameters and associated test methodology can be addressed for E20/25 fuels, there are some fundamental aspects of a potential specification to be considered as a first step, since these form the basis of the specification framework. These areas can appear more political issues than technical, in that opinions can be diverse, but the technical issues cannot be addressed without prior political agreement on the targets. This was quite evident in the stakeholder discussions, which highlighted again the key problem areas:

- Blend level – what should the optimum level of ethanol blend be, 20%, 25% or in between?
- Blend range – is it better to have a narrow allowable range or wider?
- Octane target – to what extent should advantage be taken of the octane boost offered by ethanol?

There has been to date no real agreement on these issues between oil and auto sectors. The challenge is to see where some degree of consensus may lie, in order then to map out what possible fuel specifications may look like on that basis.

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5. Scope

The scope of this work covers the development of a potential technical specification for E20/25, including an assessment of the parameters involved, possible minimum and maximum limits for these parameters, and a consideration of the analytical methods which may be applicable to build into a CEN standard. Blend level scenarios are relevant, as are thoughts around blending range and related parameters. The deliverable is a potential technical specification for E20/25 petrol.

Debates around the need (or not) for a second RUFIT (Rational Utilisation of Fuels in Private Transport) study including determination of Well to Wheels CO_2, or an impact assessment from the European Commission, are outside the scope of this report. If highlighted strongly by stakeholders, however, then it will be mentioned in this report. (Note: the original RUFIT study[7] was carried out by CONCAWE and reported in 1978. Its objective was to clarify the interrelationship between energy economy, fuel quality and emission standards, particularly in a period of moving towards unleaded gasoline, and it evaluated the crude requirements and refining costs of manufacturing gasoline at different octane qualities and lead levels.) Similarly, concerns around GHG emissions and the choice of Well to Wheels or Tank to Wheels approaches, are beyond the scope of this study.

Also out of scope is the need for protection grades, the organisation of fuel infrastructure and pump labelling matters, as well as availability and sustainability of biofuels.

Strong political support, and a robust timeframe for mandatory scale up is seen by all as vital to guarantee a smooth and cost-effective launch for any new fuel grade, but again is outside the scope of this discussion

6. Blend level

6.1 Oil Companies point of view

The blend level target is key. For oil companies, other important technical areas are infrastructure and supply aspects. For some, issues arise beyond E15 in their tank systems through supply chain from depot to petrol station. They believe OEMs do not want incremental steps but prefer to jump straight to, say, E25, but this is more expensive for oil companies. Going beyond E15, costs may rise even more due to infrastructure needs. Beyond E18 there may be a need to change metalwork in terminals due to corrosion, although may be influenced by the nature of the tank coating as well as water content of the fuel. Beyond E23 (or E25) potential for galvanic corrosion is introduced. Optimum level of efficiency is seen by some at E18 to E20 (or maybe E22-23?), but the overall view appears to be that E20 strikes the right balance against increased infrastructure costs. E20 seems to

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be the level supported by the oil sector as the most reasonable. There is little enthusiasm for exceeding this. They see more compatibility for E20 than with E25.

Additionally, from a logistics point of view, the blend level will impact directly the number and type of BOB (blendstock for oxygenate blending) which would need to be managed. According to WG38, high ethanol blends would require a special BOB with lower vapour pressure, modified distillation characteristics and reduced octane to meet the current EN 228 specification[8]. Today, generally only one base blendstock is used for RON 95 covering E5 to E10, and another one for RON 98. Avoiding an increase in the number of BOB formulations to be used in Europe is desirable. To be able to use the same BOB for all fuels, a new specification, different to that of EN228, would have to be considered. Different types of BOB are used in other non-EU countries (e.g. US).

6.2 OEMs Point of view

Market introduction of new fuels generally go through the following steps[9]:

1. Introduce of capable cars
2. Build infrastructure for the availability of the fuels
3. Introduce optimised vehicles

In the auto industry, again the preference seems to lean towards E20, with some OEMs stating E20 compatibility is currently in place for certain models, and a few manufacturers who claim that they have E25 compatible vehicles already. Some OEMs do not favour the approach of proceeding stepwise through E20/25 compatible to E20/25 optimised, as it is more costly and offers no apparent advantage, but others disagree. This concept of stepwise progression has been raised by WG38.

According to some OEMs, optimised vehicles for E10 (Euro 6 standards) are also capable of operating in an acceptable manner (driveability and emissions) at up to E20. This would support the view that limiting at 20% blend level would facilitate vehicle adaptation in the future.

Retro-compatibility for older cars is an understandable fear for OEMs. They have made it clear that no retro-compatibility system will be set as it was done for E10, implementation of which was impacted adversely by this. This was also reinforced by WG38 that E20/25 petrol can only be considered looking forwards, and backward compatibility with the older vehicle fleet (including at that time the E10 compatible fleet) cannot be considered[10]. Furthermore, a dedicated fuel (such as E85) is also undesirable for OEMs as dedicated cars, with a small number of potential customers, are needed.

6.3 Opportunities for E20/25 petrol

E20/25 fuel is seen by many OEMs as a positive means to optimise the combustion process in engines, allowing downsizing or turbo charging, which will be a key contributor to

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reducing fuel consumption, to lower tailpipe emissions of CO_2 and other pollutants in the future. According to WG38, E5 and E10 were introduced for additional reasons, including CO_2 elsewhere in the life cycle, benefits which would apply to E20/25 petrol regardless of whether the opportunity to capitalise on higher octane is seized[11].

There was some desire in OEMs for greater than E20 (one mentioned E22 specifically). Between E20 and E25 there is a change in technology as one goes towards flex fuel (the cross-over is at E22), so E20 could be an effective limit at this stage. There is at present little enthusiasm to go through an intermediate grade such as E15, as this would cause confusion to customers, and complicate the operations at service stations as they are limited in the number of grades they can accommodate. Nevertheless, E15 should not be ruled out – it would enable the 10% RED target to be achieved. There is however, a feeling that OEMs want something in return – and this is octane (see later).

OEMs see a process which would reach a compromise on an E20/25 blend, with a subsequent debate on RON. The actual blend level is not directly linked to RON.

In summary, and derived from the various discussions with stakeholders, there would appear to be more consensus around a 20% blend level (E20) as the target. There is, however, still some interpretation around the exact numerical percentage.

In other points raised, there is a strong will to avoid national specifications from all parties, and a need for EU-wide availability of fuel, preferably from a single date.

7. Blend range

In general, oil companies prefer the flexibility offered by an extended range, whereas OEMs favour a narrower range. The range is important and does impact octane requirements.

The existing blend range for E10 fuel is 0-10%. If a target fuel were to be E20, it is accepted that a range of 0-20% is too great, and would create concerns for consumers at the pumps as they may be unclear about what fuel they were buying. In this case, 10-20% may be workable, although 15-20% would be the choice of the auto sector which seeks a narrow range of 5 to 6%. A move to 15-20% for an E20 may ensure that RON 98, say, is easier to achieve. The WG38 report states[12] "that it is highly desirable that the range between minimum and maximum ethanol content (or min and max oxygenate content) is narrow, approximately 5 % (V/V) in the case of ethanol content".

The oil view is that a narrow blend range is not really necessary, as fuel sensors exist that are able to relay blend information to engine management systems, which then adapt the running of the engine accordingly. E10-20 is, however, possible for an E20 fuel.

A 5% blend range is assumed for this report, e.g. 15-20% for E20, 20-25% for E25

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8. Octane (RON/MON)

The ‘octane rating’ of a fuel is a measure of its performance in an engine, and its resistance to ‘knock’. It is an index relative to a standard of 100 for a test mixture of iso-octane and heptane. There are two octane ratings in common use - Research Octane Number (RON) and Motor Octane Number (MON). RON is measured in a test engine under standard conditions; MON is measured similarly, but under conditions of heavier load of the engine. It is RON which is more commonly quoted when defining fuel quality in terms of octane. RON is more associated with describing knock characteristics, and MON with pre-ignition performance.

E20/25 petrol offers the potential for engine technology to take advantage of lower tailpipe emissions, and a raised RON and MON. These need to be raised to achieve a CO_2 benefit on a Tank-to-Wheels basis[13].

Addition of ethanol to gasoline offers a significant octane boost, which is greater the lower the starting RON of the BOB. It offers more octane than hydrocarbon streams. This offers potential for downsizing and turbo boosting of engines, with associated improved fuel economy implications. Recent work within the EFTF[14] indicates that 75% of the RON and 98% of the MON octane boost benefit is achieved near E20/25 levels of blending.

RON for E20/25 is arguably more important than that for E10, where an expensive give-away can exist. For example, a standard E20 with RON 95 could be blended easily without the so-called ‘octane give-away’. Octane give-away is where the actual octane is higher than the minimum indicated at the pump. It is also a term used when the fuel has a higher octane rating than the vehicle for which it is used is calibrated. To avoid octane give-away, the octane level requirement should be geared to an existing, available BOB plus ethanol up to the necessary blend level. Furthermore, modern cars are able to utilise any octane increase to best effect and negate any give-away.

Octane gain from an additional 10% ethanol is about 3 points RON. The key message is that ethanol, and other oxygenates, can provide a significant octane benefit.

A typical oil industry position is E20 with RON 95, but it is recognised that higher octane is needed in new fuels to allow supercharged engines. It is possible to achieve higher RON, say 98, using splash-blending with an existing BOB. Note that this will be dealt with in tasks 2 and 3 of the overall E20/25 study. Again, the octane give-away can be avoided.

Target octane (RON/MON) levels provoke the most disparate views, principally between the oil industry which wants low values, and the auto industry which wishes to take advantage of the benefits of higher octane offered by the use of ethanol. RON is the most critical parameter.

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Some OEMs have pushed for 102 but this is regarded as too high for oil companies. The general feel within oil is that 97-98 RON may be a compromise.

There is some opinion that OEMs may not really want RON to be too high in case not enough service station pumps are available for this grade, if they produce E20/25 optimised vehicles. Again, there is a feeling within several OEMs that minimum RON should be (at least) 98, because that would help them save some extra grams of CO_2, although one OEM felt that the combination of E20 and RON 102 is a good compromise between CO_2 benefit and fuel economy penalty. In general the auto industry is thinking of higher RON (>100) as a mechanism to improve engine efficiency, and ideally would like up to RON 103-104. What is certain is that it must be higher than 95-96, according to some OEMs, otherwise there is little incentive in terms of CO_2 savings. Nevertheless, E20/25 should be beneficial for CO_2 emission reduction whatever the RON level. Higher octane is the clearest item on the auto industry wish list. It should be noted that RON 98 is readily available throughout Europe at present. The auto industry's Worldwide Fuel Charter[15] recommends a minimum of RON 95.

Currently the test methodology for measurement of high octane (>100) levels is not adequate, and a suitable test method would be needed above RON 100. There is also a shortage of lead-containing primary reference fuel for the test measurement above RON 100[16]. Work on this topic is ongoing within the EFTF. The current method is limited not only in terms of maximum RON that can be measured, but also the maximum oxygen content.

For the purpose of this study, a RON target of 98-100 is assumed.

9. Oxygenate mix

It is foreseen that the wording of EN 228:2012[4] Section 5.1 would be followed in any E20/25 specification, viz "Unleaded petrol may contain up to xx,0% (V/V) of ethanol complying with EN 15376". EN 15376[17] is the European standard for ethanol as a blend component for petrol, and is currently under review by the EFTF. Any new E20/25 petrol specification will allow for the blending of other oxygenates, as is the case at present within the current (E10) EN228:2012.

E20/25 fuel could be formulated with the required percentage of ethanol. Ethanol has been widely used in biofuel blends not least because of its octane-enhancing capability. Alternatively, E20/25 could contain a mix of ethanol and ETBE – as an example for E20, say, 15% 'free' ethanol and 10% ETBE (providing a 10% ethanol equivalent). With this blend as an example, there may be benefits in less difficult engine design and fuel injection technology.

Nevertheless, with ETBE RON of 117, there would still be an octane benefit from both oxygenate components. This approach would raise questions around ETBE availability

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(particularly outside France), cooling effects relative to ethanol, and relative CO2 emission reduction performance. It is an approach, however, which merits further thought.

Desire from oil companies for flexibility of oxygenate type has been expressed. Ethers, butanol, and even biomethanol were mentioned in this context, and each has its pros/cons in relation to octane boost, fuel consumption, ease of blending and other parameters. Methanol is seen as a component that should be limited severely, due to its toxicity and physicochemical properties[18]. Nevertheless, **this report will focus upon ethanol as the oxygenate blending component.**

10. Volatility (Driveability)

Volatility characteristics, in terms of vapour pressure and distillation behaviour, and the impact upon driveability, have been a significant area for scrutiny, both within the WG38 report and in the recent review of EN 228. These must be controlled on a seasonal basis so that vehicle driveability is not affected adversely as climate conditions change.

Vapour pressure (VP) is controlled according to seasonal needs, but also to accommodate high temperature operation, and improve cold start performance. VP is often expressed as Dry Vapour Pressure Equivalent, or DVPE. Ethanol in a blend with petrol increases DVPE at low levels[19]. For example, addition of only 2% by volume of ethanol can increase the VP of the fuel by a significant 6 to 8 kPa. Addition of more than 10% by volume of ethanol results in a gradual reduction in VP – an effect reflected in the Fuel Quality Directive DVPE waiver. Such physical behaviour emphasises the importance of the blending range as this will define the variation of ethanol content possible in fuel storage and distribution systems.

Much work has been done on defining distillation curves for ethanol-petrol blends, and the role of Distillation Index in cold start performance. Such curves plot the percentage of fuel evaporated against temperature. The term Exx represents the fraction evaporated at a temperature of xx ^{o}C. Such plots are not linear, and there is some 'flattening' of the curves as ethanol content is increased. This will need to be taken into account when defining the minimum and maximum limits on volatility for higher ethanol blends.

E70, the evaporated fraction at 70^{o}C and E100, the evaporated fraction at 100^{o}C, are the measures used currently, but may need to be reassessed to confirm they are the most suitable for higher ethanol blends. T values may be needed instead (Txx is the temperature at which xx% of the fuel is evaporated). E70 is more of a problem than E100.

In the current EN 228[4], Annex A gives the permitted vapour pressure waiver for different levels of ethanol from 0 to 10%. Such a table would need to be developed also for E20/25, but over the narrower blend range, e.g. 15-20 or 20-25%. Fuel blenders are keen that mixing with either a base of BOB 10% or a BOB 20% is allowed.

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Driveability remains a subject of critical importance. It is essential to specify distillation limits which preserve acceptable driveability. Some argue that different descriptors of volatility may be required. Yet for some OEMs, vehicles optimised for E10 (Euro 6 standards) can operate in an acceptably using E20 petrol. Certainly, E20 petrol blends, for example, can be prepared which comply with the requirements of the latest version of EN 228, and which should not therefore pose any driveability problem. Further examination of this area is required to define criteria for VP and distillation behaviour in an E20/25 specification.

11. Parameters and test methods

A European standard for ethanol, for blending at all levels up to and including 85%, is under development by the EFTF. Work is underway also within that group to develop the CEN/TS for E85 into a full EN standard. A revised EN 228 for unleaded petrol, covering E10, has been published in 2013[4]. A specification for E20/25 fuel should reflect the requirements of EN 228 as a starting point, although not all parameters may be applicable, and there may be additional parameters to be considered.

The following possible parameters, and associated test methods are considered below, in the context of an E20/25 fuel. The parameters are based firstly upon current EN228 requirements, but also with regard to additional parameters which may be appropriate due to the increased level of ethanol from E10 to E20/25. Obviously all parameters considered for inclusion in the specification must have at least one valid measurement technique available, which has been verified as applicable to E20/25 and to the relevant measurement range, with acceptable precision. Confirmation of applicability, where relevant, would need to be carried out by suitable inter-laboratory test programmes. Analytical methods are suggested based upon their applicability within current specifications, the possible measurement range and precision expected.

11.1 EN 228 parameters

Octane

Limits: Currently RON 95.0 min and MON 85.0 min in EN 228. For E20/25, min RON could be 98 and MON 86 (see above) but presently between 95 and 104. Agreement required from oil/auto.

Methods: EN ISO 5164 and EN ISO 5163 for RON and MON respectively. Both methods currently being reviewed. Precision beyond RON 100 is uncertain, but should be suitable for E20 at RON 98 to 100. ASTM work on equivalent methods has demonstrated applicability for up to E25.

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Lead

Limit: Currently 5.0 mg/l max in EN 228. Same limit for E20/25.

Methods: EN 237 (AAS), likely to be applicable to E20/25.

Density

Limit: Currently 720.0 min to 775.0 max kg/m^3 at 15degC in EN 228. For E20/25, max is expected to be higher and may be up to 790 kg/m^3 but this needs to be confirmed.

Methods: EN ISO 3675 (hydrometer) and EN ISO 12185 (DDM). E20/25 is within calibration range of meters. EN ISO 12185 may be preferred method. Temperature correction factors may need to be generated for E20/25.

Sulfur

Limit: Currently 10.0 mg/kg max in EN 228. Same limit likely for E20/25.

Methods: EN ISO 13032 (XRF), EN ISO 20846 (UVF), EN ISO 20884 (WDXRF) in EN 228. For WDXRF, precision may be affected by increased oxygenate content and would need checking. UVF should be unaffected. Also, an ICP technique may be applicable, but would need further development.

Manganese

Limit: Currently 2.0 mg/l max in EN228, from 2014-01-01. Same limit for E20/25.

Methods: EN ISO 16135 (FAAS) and EN ISO 16136 (ICP) in EN 228. Need to be checked for applicability to E20/25.

Oxidation stability

Limit: Currently 360 minutes min in EN 228. Same limit for E20/25, as for E85.

Methods: EN ISO 7536 (induction period) is suitable for E5, E10 and E85, hence OK for E20/25.

Existent gum

Limit: Currently 5 mg/100ml max in EN 228. Same limit for E20/25, as for E85.

Methods: EN ISO 6246 (jet evaporation). Precision likely to be suitable but may need Round Robin test to confirm.

Copper strip corrosion

Limit: Currently Class 1 rating for 3h at 50 ^{o}C in EN 228. Same limit for E20/25, as for E85.

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Methods: EN ISO 2160 is suitable but precision to be checked.

Appearance

Limit: clear and bright in EN 228. Same for E20/25.

Method: Visual inspection

Hydrocarbon type content

Limit: Currently 18.0 % (V/V) max for olefins and 35% (V/V) max for aromatics in EN 228. Similar limits for E20/25 expected, although if aromatics are lowered then RON would increase. Issue is whether oxygenate-free figures for hydrocarbon type are corrected for the oxygen content of the ethanol. Requires further check / discussion.

Methods: EN 15553 (FIA) and EN ISO 22854 (GC). RR could be required for FIA. GC method applicable, but could be confirmed via a ruggedness study.

Benzene

Limit: Currently 1.00 % (V/V) max in EN 228. Same limit for E20/25.

Methods: EN 238 (IR) and EN 12177 (GC) can be problematic at high ethanol levels, and in any case are declining in use. EN ISO 22854 (MDGC) is confirmed able to determine benzene up to 2.0 % (V/V).

Oxygen

Limit: Currently 3.7 % m/m max in EN 228. Limit of 7.4 % m/m for E20, 9.25 % m/m for E25.

Methods: EN 1601, EN 13132, EN ISO 22854 in EN 228. EN 13132 unlikely to be an acceptable method for E20/25 as all oxygenates present must be defined. This method and EN 1601 are declining in use and availability of lab facilities. Modified version of EN ISO 22854 is being developed by CEN/TC19/WG9 which should be suitable.

Oxygenates

Limits: Currently in EN 228 are the following limits, expressed as % (V/V). In parentheses would be suggested limits for an example E20 based on equivalent oxygen:

Ethanol 10.0 (20.0), iso-propyl alcohol 12.0 (24.0), iso-butyl alcohol 15.0 (30.0), tert-butyl alcohol 15.0 (30.0), ethers (5 or more C atoms) 22.0 (44.0), other oxygenates 15.0 (30.0).

In the case of methanol, the current EN 228 limit is 3.0 % (V/V). This is likely to remain at this level for E20/25, as an accepted industry maximum for this component.

Methods: EN 1601, EN 13132, EN ISO 22854 in EN 228. EN 13132 unlikely to be an acceptable method for E20/25 as all oxygenates present must be defined. This method and

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EN 1601 are declining in use and availability of lab facilities. Modified version of EN ISO 22854 is being developed by CEN/TC19/WG9 which should be suitable.

Volatility

In the current EN 228, ten volatility classes are defined, which are characterised by the following parameters:

- vapour pressure, E70, E100, E150, final boiling point, distillation residue, and vapour lock index

In terms of the limits which should apply to E20/25, and indeed whether all of these parameters are appropriate for E20/25 or should other descriptors be applied, then much more detailed debate needs to take place. Nevertheless, at this stage it seems reasonable to set an initial maximum DVPE at the existing DVPE limits, i.e.

Class	A	B	C/C1	D/D1	E/E1	F/F1
kPa, max	60.0	70.0	80.0	90.0	95.0	100.0

It may be possible that the DVPE Waiver could be set at the existing E10 limit, namely 7.8 kPa.

Methods: For vapour pressure, EN 13016-1 is the method of choice in EN 228, and it allows calculation of a Dry Reid Vapour Pressure (DVPE) equivalent. Available methodology should suffice for E20/25 and the method is suitable for E85. The method is under revision by CEN/TC19/WG15. Work on a triple expansion method is also underway in WG15 and will be compared with DVPE. RR work is planned, possibly in combination with ASTM. Acceptance for use in EN 228 would be by WG21.

Distillation characteristics are determined by EN ISO 3405, and cover E70, E100, E150, final boiling point, and distillation residue. Applicability and precision for E20/25 needs to be investigated.

11.2 Potential additional parameters

Certain other parameters of interest are controlled in the ethanol specification EN 15376[17] and therefore should not need to be incorporated into the E20/25 specification. These are:

- Water
- Total acidity
- Electrical conductivity
- Inorganic chloride
- Sulfate
- Copper

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- Phosphorus
- Involatile material

Should any of these parameters be included in the E20/25 specification, applicability of existing methods would need to be assessed.

For the determination of high-boiling components including FAME in petrol, EN 16270 is the GC method used. CEN/TC19/WG9 is currently working to confirm its applicability for E85, and should also be able to be used for E20/25 if necessary.

12. Potential E20/25 specification

From the above, it becomes a little clearer what a potential E20/25 could be. For the purpose of this report, E20 is taken as a hypothetical example of how one specification for E20 compatible cars could look like:

• Blend level	20% (E20)	reasonable consensus around this level
• Blend range	15 to 20%	
• Oxygenate	Ethanol	assumed for this report
• Octane	RON 98 min	MON 86 min

Annex 1 summarises the parameters and test methods that could form the basis of a possible specification. Several parameters and test methods should not be problematic. Some stakeholders indicated that it would be useful to highlight those parameters which may not be problematic, and those where deeper consideration would be needed. This is reflected in the colour-coding in Annex 1. Areas where there needs to be further work and/or consensus are indicated. It should be re-emphasised that Annex 1 should be considered as a first draft of how a specification might look, using E20 as just an example and not a definitive recommendation.

13. Conclusions

The current study project on E20/25 petrol specifications, of which this report forms part, aims to move forward from previous work on E10+ fuels.

This first stage of the project has reviewed some key issues and the applicable parameters and test methods for such fuels, through 1:1 meetings and discussions with key stakeholders. It will provide input to the next stages of this study, the meta-analysis and the car trials.

What the target blend level should be is perhaps the most crucial question. On the oil side, E20 seems to be the level of most general support; OEMs have a similar view, and some

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claim E20 compatibility even now. So there seems some degree of consensus at or around this level. A definitive blend level would still need to be fixed in due course.

There is different opinion about the optimum blend range between oil and auto sectors, and although a 10% range may be workable, a narrower range of 5% appears to have more support.

Opinions on some aspects are quite polarised across the stakeholders. A strong example is on octane targets. The oil industry seek low RON, whereas the auto industry want high – it could be possible to gain a consensus around 98-100 and at the same time address concerns on octane giveaway.

This report has focused upon ethanol as the main oxygenate component for blending of E10+ fuels, due to its widespread use in biofuel blends.

Driveability, and its preservation, is of utmost importance. There has been much debate around the necessary characteristics of vapour pressure and distillation behaviour as a means of expressing driveability, and further consideration will be needed on this matter. Nevertheless, it is perhaps reassuring that many existing vehicles are even now E20 compatible, so this ought not to be an intractable issue, even without E20 optimisation.

Although possible specifications for E20/25 have stimulated much debate, there are many areas which are not controversial, and it is useful to separate these from those areas which require more attention. This has been attempted in the Annex.

Parameters such as lead, density, sulphur, oxidation stability, appearance, and benzene should need little discussion on both limits and test methods.

Certain parameters need much more debate. Octane targets need to be agreed, and if the RON target is to exceed 100, then a suitable test method needs to be developed. Volatility parameters, as mentioned above under driveability, need reviewing.

There are several parameters where a specification limit should be relatively straightforward but where the test methods need to be checked for sufficient precision in E20/25 fuels, for instance: manganese, existent gum, copper strip corrosion, and hydrocarbon type content.

Several other parameters would be controlled by the ethanol specification EN 15376 and need not be built into a new specification for E20/25.

An output from this part of the study is a first view on how a specification for E20/25 petrol might look, and it is hoped that this will facilitate the steps to come.

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14. Future process / next steps

It is planned that a workshop will be held in 2014, after the outputs of the meta-analysis and the car trials are known. It is intended to bring together discussion amongst technical experts on this report in light of the findings of the meta-analysis and car trials.

The experts will be drawn from the relevant stakeholders, principally the oil, auto and ethanol sectors. The aim is to work towards a consensus on how an E20/25 specification could look, in terms of parameters included, potential range and limits, and appropriate test methods, using this report as a basis. Areas of difficulty will be highlighted and recommendations made for any further work required.

The workshop will not seek policy commitment from stakeholders – it is to be a technical discussion on what might be possible on a technical basis.

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Annex 1 **E20/25 - Parameters for Potential Specification - DRAFT**

(Based on E20 as an example, for compatible cars)

Parameter	**Units**	**Value**	**Limits**	**Method**	**Comments**
EN 228 parameters					
Octane	RON	min	98.0	EN ISO 5164	Agreement needed
Octane	MON	min	86.0	EN ISO 5163	Agreement needed
Lead	mg/l	max	5.0	EN 237	OK
Density	kg/m^3	range	720.0 min 790.0 max	EN ISO 3675 EN ISO 12185	OK. EN ISO 12185 preferred
Sulfur	mg/kg	max	10.0	EN ISO 13032 EN ISO 20846 EN ISO 20884	ICP possible also
Manganese	mg/l	max	2.0	EN ISO 16315 EN ISO 16136	Check applicability
Oxidation stability	minutes	min	360	EN ISO 7536	OK
Existent gum	mg/100ml	max	5	EN ISO 6246	May need RR
Copper strip corrosion	rating	rating	Class 1	EN ISO 2160	Check precision
Appearance			Clear and bright	Visual inspection	
Hydrocarbon type content	% V/V	max	Olefins 18.0 Aromatics 35%	EN 15553 EN ISO 22854	Check precision
Benzene	% V/V	max	1.00	EN 238 EN 12177 EN ISO 22854	EN ISO 22854 preferred
Oxygen	% m/m	max	7.4	EN 1601 EN 13132 EN ISO 22854	EN ISO 22854 preferred
Ethanol	% V/V	range	15.0 min 20.0 max		
Other Oxygenates	% V/V	max	Methanol 3.0 iPr alcohol 24.0 iBu alcohol 30.0 tBu alcohol 30.0 ethers 5C+ 44.0 other 30.0	EN 1601 EN 13132 EN ISO 22854	EN ISO 22854 preferred. Confirm limits

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Possible related parameters					
Water	% m/m	max		EN 15489 EN 15692	Not needed?
Total acidity	% m/m	max		EN 15491	Not needed
Electrical conductivity	µS/cm	max		EN 15938	Not needed
Inorganic chloride	mg/kg	max		EN 15492	Not needed
Sulfate	mg/kg	max		EN 15492	Not needed
Copper	mg/kg	max		EN 15488 EN 15837	Not needed
Phosphorus	mg/kg	max		EN 15487 EN 15837	Not needed
Involatile material	mg/100ml	max		EN 15691	Not needed?
High boilers	% V/V	max		EN 16270	Not needed?
EN 228 Volatility parameters					
Vapour pressure	kPa	range	60.0 to 100.0 Class A to Class F/F1	EN 13016-1	
E70	% V/V	range		EN ISO 3405	
E100	% V/V	range		EN ISO 3405	
E150	% V/V	min		EN ISO 3405	
Final boiling point	°C	max		EN ISO 3405	
Distillation residue	% V/V	max		EN ISO 3405	
Vapour lock index	index	max			

Key:

Priority area for further attention	Should not be problematic To be assessed further	Not problematic

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