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Concawe Substance Identification Group

Analytical Program Report (Abridged Version)

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ABSTRACT

This report describes the work undertaken and results obtained from the Concawe 2015 Analytical Program, which involved the chemical characterisation of 189 petroleum substances from 20 substance categories. As a limited number of samples were analysed per substance and in light of the Unknown or Variable Composition, Complex Reaction Products and Biological Materials (UVCB) nature of petroleum substances, the report provides supporting information only and should not be regarded as definitive for any substance.

To avoid the possibility that any analytical data presented can be attributed to a sample provided by a specific REACH registrant, the identities of 29 substances for which there are fewer than 3 active registrations have been "anonymised" by identifying only the category to which they belong. A further 6 petroleum substances for which there is only a single active registration within a category are omitted from this report. A full report on the 2015 Analytical Program includes data on all 189 substances and is available to Concawe secretariat only for reference purposes.

Given that, for most substances, this report relates to one sample per substance, Concawe is now combining these data with additional information to conduct a statistical analysis of the similarity between substances within a category. This information is relevant in the optimisation of human health and environmental hazard testing.

KEYWORDS

petroleum substance, substance identity, analytical chemistry, UVCB, composition

INTERNET

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SUMMARY

This report describes the work undertaken and results obtained from the Concawe 2015 Analytical Program (AP), which involved the chemical characterisation of 189 petroleum substances (PS) from 20 substance categories. The 2015 AP extended a similar project carried out in 2013 but which only involved the characterisation of PS from 5 substance categories for which testing proposals were being submitted.

Samples of virtually all the substances investigated were first examined to check whether their composition was consistent with the formal substance description of the registered substance, most of which include an approximate carbon number and/or boiling point range. The samples were then examined in greater detail using a range of analytical techniques depending on their physical characteristics and chemical complexity.

The results obtained on the substances investigated are presented in this report together with comparisons of equivalent results obtained on the same samples analysed using different analytical techniques and, with few exceptions, show that:

- Results obtained on the same samples analysed in 2013 and 2015 are in good agreement.
- The chemical compositions of the samples analysed are consistent with their formal substance descriptions.
- Equivalent results obtained on the same samples using different techniques show good agreement.
- Spectroscopic analysis of PS provides no useful additional information for substance identification to that generated by the standard chromatographic techniques.

Note

This is an abridged version of the full report on the 2015 AP in which the analytical results generated on 6 substances for which there is only a single registration within a category have been excluded; and the identities of 29 substances for which there are fewer than 3 active registrations have been "anonymised" as shown in the table below. This has been necessary to avoid the possibility that any analytical data presented in this report can be attributed to a sample provided by a specific registrant.

Category of "anonymised" substance	Substance identifiers used in this report	Number of "anonymised" substances
Low Boiling Point Naphthas	Naphtha 1 - Naphtha 14	14
Other Lubricant Base Oils	OLBO 1 - OLBO 6	6
Kerosines	Kero 1 - Kero 4	4
Cracked Gas Oils	CGO 1 - CGO 3	3
Heavy Fuel Oils	HFO 1 - HFO 2	2
Total number of "anonymised" substances		**29**

1. INTRODUCTION

REACH Regulation (EC) No 1907/2006 (Annex VI, item 2) includes general information and certain key principles for substance identification and states that the information submitted to support a registration should be sufficient to enable the substance to be identified, adding that if this is not technically possible or not considered scientifically necessary then the reasons should be clearly stated. Annex VI item 2 lists some eighteen sub-items to be considered for substance identification and refers to specific analytical information requirements, namely: spectral data (ultra-violet, infra-red, nuclear magnetic resonance or mass spectrum); and high-pressure liquid chromatogram, or gas chromatogram.

The PS involved in the 2015 AP are defined as UVCB (Unknown or Variable composition, Complex reaction products or Biological materials) substances and the REACH Regulation provides specific information for these materials. As previously described (1), PS vary tremendously in their chemical complexity: the lighter substances (e.g. LBPN; ~C4-C10) contain a few hundred individual components whereas middle-distillates (e.g. SRGO; ~C10-C25) contain many thousands of components and heavier substances (e.g. HFO; >C20) contain millions of individual components. The rapid increase in complexity with carbon number not only arises from the vast number of isomers present but also from the increased chemical functionality within individual compounds which means that, even if we could identify and quantify each individual component present in an HFO, it would not be feasible to employ a uniform set of chemical descriptors to provide a detailed classification of all the components present in all PS.

Because PS span such a wide range of components with widely different volatilities and polarities it is not possible to characterise all these substances using the same suite of analytical techniques. Concawe therefore recommends using a structured analytical approach tailored to the properties of each PS rather than employing a standard suite of analytical procedures as stated in the REACH Regulation and believes that some of the analytical data requirements specified in the Regulation provide no useful information for PS identification. Moreover, Concawe has always encouraged the use of standard industry methods for characterising PS because these methods have been developed and validated by the petroleum industry and are accepted by competent authorities and customers because they provide a strong technical basis for confirming consistent product quality and assessing potential health, safety and environmental hazards associated with these materials. Concawe therefore developed guidance (2, 3) based on standard industry methods to help member companies decide which analytical information they should include in IUCLID files when registering PS under REACH.

1.1. 2013 ANALYTICAL PROGRAM

Following discussions with ECHA, Concawe carried out an AP in 2013 which involved the chemical characterisation of PS from 5 substance categories (SRGO; OGO; VHGO; RAE; Bitumen) for which testing proposals were being submitted. **Table 1** shows the PS which were investigated in this project. Because testing proposals were being submitted for some of the substances, registrants were requested to supply large volumes (~20 L) of these materials so that any subsequent testing programs could be carried out on the same PS sample used for chemical characterisation. Large volumes of all samples shown in **Table 1** (except for CON 10) were eventually received but, owing to delays in obtaining two SRGO samples (CON 3 and CON 4), Concawe sought replacement samples of these two substances which were then designated CON 3I and CON 4I to differentiate them from the original samples. No chemical characterisation work was carried out on CON 10 because it was not possible to obtain a large volume sample of this material.

The samples shown in **Table 1** were examined using both the methods recommended by Concawe for the appropriate substance categories (2) and, because some samples were expected to be used as test substances in subsequent studies, by additional procedures (e.g. GCxGC; GC-MS; PAC-2) to provide supplementary information on components (e.g. PAHs) present in the samples. The analytical work carried out on these samples is summarised below:

SRGO; OGO; VHGO

- Simulated distillation gas chromatography (SIMDIS-GC) to provide information on the boiling and carbon number ranges of the components present.
- Comprehensive two-dimensional gas chromatography (GCxGC) to provide quantitative information on the types of chemical functionalities present for each carbon number.
- High performance liquid chromatography (HPLC) to provide the total contents of mono-, di- and tri+ aromatic hydrocarbons present.
- High resolution gas chromatography-mass spectrometry (GC-MS) to provide information on the quantities of EPA and Grimmer poly-aromatic hydrocarbons (PAHs) present.
- Dimethyl sulfoxide (DMSO) extraction and GC-MS of the extract to provide information on the total quantities of 1, 2, 3, 4, 5, 6, 7+ ring poly-cyclic aromatic carbon (PAC) compounds present (PAC-2 analysis).

RAE; Bitumen

- SIMDIS-GC to provide information on the boiling and carbon number ranges of the components present.
- Thin layer chromatography with flame ionisation detection (TLC-FID) to provide quantitative information on the basic chemical functionalities (saturates, aromatics, resins, asphaltenes) present.
- High resolution GC-MS to provide information on the quantities of Grimmer and EPA poly-aromatic hydrocarbons (PAHs) present.

The detailed results obtained on all 30 samples analysed in the 2013 AP have been reported individually [4 - 33], and a summary of these results is shown below:

SIMDIS-GC results obtained on samples CON 1, CON 3, CON 4, CON 6, CON 7, CON 9, CON 11, CON 12, CON20, CON 21, CON 22, CON 23, CON 24, CON 25, CON 26 and CON 27 were in relatively good agreement with the corresponding substance descriptions shown **Table 1**. The substance descriptions for CON 17, CON 18 and CON 19 do not specify boiling or carbon number ranges, and the substance descriptions for samples CON 23 and CON 24 are somewhat inconsistent (i.e. >C34 and >495°C vs. >C50 and >360°C).

For the other samples: ~25% of CON 2 was above the specified boiling range; CON 3I was lighter than the specified boiling range; although the boiling range of CON 4I agreed with the substance description the sample appeared to consist predominantly of n-paraffins; ~ 50% of CON 5 was above the specified boiling range; CON 8 had a much narrower boiling range than that specified; CON 13 was somewhat heavier than the specified boiling range; ~40% of CON 14 was above the specified boiling range; CON 15 was lighter than the specified boiling range; CON 16(i) and CON 16(ii) had broader boiling ranges than that specified, and ~30% of the CON 16(iii) was above the specified boiling range for this substance.

GCxGC results on the SRGO, OGO and VHGO samples showed that: CON 13 and CON 20 contained heavier range components than the other samples and that the highest concentrations of tri-aromatic hydrocarbons were found in CON 4 (3.38%) and CON 13 (2.90%); with the exception of CON 20 (2.47%), the hydrotreated samples (CON 7, CON 8, CON 9, CON 11, CON 14, CON 15) contained low concentrations (≤0.65%) of tri-aromatic hydrocarbons; CON 8 contained a high concentration of naphthenic components and a relatively low concentration of paraffinic components; CON 16(i), CON 16(ii) and CON 17 also contained low concentrations of tri-aromatic components but, according to the supplier, CON 16(i) and CON 16(ii) contained either a large quantity of kerosine or kerosine blended with hydrotreated gas oil, both of which would have a low tri-aromatic hydrocarbon content.

HPLC results on the SRGO, OGO and VHGO samples showed that, despite these data being obtained using a completely different measurement system (HPLC-RI) to GCxGC, there was generally good agreement between the results generated using these two techniques. There was some discrepancy for CON 13 which probably arose because it contained some heavier components which were slightly outside the normal measurement range for GCxGC, but HPLC showed that CON 13 contained the highest concentration of tri+aromatic hydrocarbons (4.2%) with CON 20 (3.3%) and CON 4 (2.8%) the next highest. CON 7, CON 8, CON 9, CON 11, CON 14 and CON 15 all contained low concentrations of tri+aromatic hydrocarbons consistent with hydrotreated materials as did CON 16(i), CON 16(ii) and CON 17.

Detailed PAH analysis results showed that CON 13 contained much lower concentrations of the lighter PAHs (2–3 ring) than all the other gas oil samples but contained the highest concentrations of the heavier PAHs (4-7 ring). CON 20 also contained significant concentrations of the heavier PAHs albeit lower than CON 13. These two samples contained the highest concentrations of the marker PAH, benzo[a]pyrene (CON 13 - 9.61 mg/kg; CON 20 - 3.12 mg/kg). CON 8 contained no significant concentrations of PAHs which is consistent with the HPLC results on this sample which showed it to have the lowest total aromatic content and to contain ≤0.1% di- and tri-aromatic hydrocarbons. Among the bitumen samples, CON 21 and CON 25 contained much higher concentrations of the heavier PAHs than the other three samples. Only very low concentrations of PAHs were found in both RAE samples.

PAC-2 class analysis results on the SRGO, OGO and VHGO samples showed that, for the 3 ring and heavier aromatic compounds, the results obtained were relatively consistent with those obtained by HPLC and GCxGC. However, the PAC-2 class analysis results for 1 and 2 ring aromatic compounds were much lower than those measured using these procedures, presumably owing to the poor efficiency of the DMSO extraction procedure for these compounds. The PAC-2 procedure (34) was designed to mimic the DMSO extraction procedure (IP 346) developed for measuring PAC compounds in base oils (35) and is therefore not suitable for the quantitative measurement of 1 and 2 ring aromatic compounds. As reported above for the detailed PAH analysis, CON 13 and CON 20 contained the highest concentrations of heavier PACs (4-7 ring) with CON 13 containing measurable concentrations of 3-6 ring PACs and CON 20 containing measurable concentrations of 3-5 ring PACs.

TLC-FID results on RAE and bitumen samples showed all these samples to contain a significant quantity (55.8% - 84.0%) of aromatic hydrocarbons. An “unknown” fraction eluting between the saturate and aromatic fractions was observed in CON 24, CON 25 and CON 26 and, given that CON 24 and CON 25 are described as hydrotreated substances, it seems plausible that this “unknown” fraction corresponds to partially hydrogenated aromatic components (e.g. naphthenic aromatic hydrocarbons).

1.2. 2015 ANALYTICAL PROGRAM

Following on from the 2013 AP, Concawe decided to extend the chemical characterisation of substances in the SRGO, OGO, VHGO, RAE and Bitumen categories to the remaining 15 PS categories. For completeness, 19 sub-samples of SRGO, OGO, VHGO and RAE samples from the 2013 AP were transferred to the 2015 AP to provide a comprehensive sample set covering all active registered PS in the 20 substance categories. **Table 2** provides a detailed inventory of all PS in the 2015 AP (minus the excluded substances), and a summary by category of all substances (including the excluded substances) is shown in **Table 3**.

Table 2 lists 203 sample numbers but this includes 11 substances which became “inactive” (e.g. no longer manufactured or imported) during the 2015 AP. These substances, which are highlighted in green in **Table 2**, were removed from the list of registered substances by Concawe leaving 192 “active” listings in the inventory.

For the following sample numbers registrants either supplied multiple samples or provided results on multiple samples of the same substance:

- 032 (11 samples) 032-258487; 032-258509; 032-261286; 032-265943; 032-265944; 032-265945; 032-262859; 032-659845; 032-664222; 032-668631; 032-258510
- 082R (3 samples) 082R-320019; 082R-300050; 082R-635001
- 085 (4 samples) 085A; 085B; 085C; 085D
- 096 (2 samples) 096A; 096B
- 098 (2 samples) 098A; 098B
- 187 (2 samples) 187(1); 187(2)
- 198 (4 samples) 198-R21; 198-R32; 198-R42; 198-R62
- Naphtha 13 (4 samples)

Replacement samples (identified by the “R” suffix) were obtained for some substances because analysis of the original samples indicated that they were not representative of the registered substance, or the supplier subsequently informed Concawe that they had sent an invalid sample, or the registrant changed during the 2015 AP; these samples (080; 082; 104; 136; 163; 183) are highlighted in mauve in **Table 2**.

Extra samples of two substances (192; 193) were obtained from the registrant because the original samples had been exhausted during the analytical investigations; these samples (identified by the “X” suffix) are highlighted in blue in **Table 2**.

For some substances the registrants did not supply samples for the 2015 AP as requested but analysed the samples in their own laboratories and provided Concawe with the results. These samples (032-258487; 032-258509; 032-261286; 032-265943; 032-265944; 032-265945; 032-262859; 032-659845; 032-664222; 032-668631; 032-258510; 159; 167; Naphtha 12; 198-R21; 198-R32; 198-R42; 198-R62; Naphtha 13) are highlighted in amber in **Table 2**.

The 19 sub-samples of SRGO, OGO, VHGO and RAE samples from the 2013 AP which were transferred to the 2015 AP are highlighted in yellow in **Table 2**. Although these samples were allocated unique 2015 AP sample numbers, **Table 2** also shows their 2013 AP sample numbers as cross-referenced in **Table 1**.

In addition to providing an inventory of all samples involved in the 2015 AP, **Table 2** also indicates those substances which had no formal substance description or where the formal description was confusing, ambiguous or inconsistent. As shown in the "Comments" column of **Table 2**, Concawe proposed new descriptions for the "active" substances (003; Naphtha 2; Kero 2; 037; 042; 045; 052; 056; 057; 058; 059; OLBO 2; 094; 099; 109; OLBO 4; 117; Naphtha 11; 164) based on the substance names and the SIMDIS-GC results.

As summarised in **Table 3** and taking account of multiple samples and replacement samples, there are 221 valid "active" samples distributed across the 20 PS substance categories in the inventory. These samples represent 188 different CAS numbers and 189 different EC numbers.

1.2.1. Strategy

The samples used in the 2015 AP were supplied by registrants in response to requests from Concawe. Following instructions from the Concawe Project Coordinator, the Sample Coordination Laboratory (SGS UK Ltd, Billingham, UK) supplied sample containers and sampling instructions to the registrants who subsequently returned samples to SGS for retention under appropriate storage conditions. Using information provided by the Project Coordinator, SGS then prepared sub-samples of these materials and dispatched them to the appropriate analytical laboratories. The analytical data generated were reviewed and collated by the Project Coordinator before being shared with the Concawe Substance Identification Group (SIG).

Originally the 2015 AP was divided into two phases:

- In the first phase all substances were examined by SIMDIS-GC, and the lighter fractions (LBPN; Kerosine) were also examined by physical distillation. These techniques provided data on the carbon number and boiling point ranges of the substances which could then be compared with the corresponding substance descriptions to check whether the sample supplied was representative of the registered substance. If the first phase analysis showed that a sample was not representative of the registered substance, then a replacement sample was requested from the supplier.

- The second phase involved more detailed analysis of all samples which were representative of the registered substances using a range of analytical procedures depending on the physical characteristics and chemical complexity of the substances.

It was recognised that all the substances supplied were spot samples and, given that all PS are UVCBs and are manufactured to specifications based on performance characteristics rather than chemical composition, analysis of the same substance manufactured in the same location at different times could show a considerable variation in composition. Moreover, **Table 2** shows that many formal descriptions of PS contain qualitative (e.g. mainly, predominantly, approximately etc) rather than quantitative (e.g. >80%) terms, which means the judgement on whether a sample is representative of the registered substance can be somewhat subjective in nature. In order to gain a more objective assessment, the procedure described in Section 2.2 and illustrated in **Figure 1** was used to decide whether the sample supplied was representative of the registered substance.

1.2.2. Analysis of Samples

As with the 2013 AP, samples from the 2015 AP were analysed using both the standard industry methods which Concawe recommended to member companies for characterising their PS (2, 3) and by a range of other procedures to provide supplementary information on the substances. Detailed information on the methods employed is provided in Section 2 but the suite of analytical procedures employed is summarised below:

First Phase

- **SIMDIS-GC**- carried out on all substances to provide information on the boiling and carbon number ranges of the components present.
- **Physical distillation** - carried out on LBPNs and Kerosines to provide information on the boiling range of these substances.

Second Phase

- **GCxGC** - carried out on most substances other than LBPNs to provide quantitative information on the types of chemical functionalities present for each carbon number.
- **DHA-GC** (Detailed hydrocarbon analysis gas chromatography) - carried out on most LBPNs to provide qualitative and quantitative information on the individual components present.
- **PIONA-GC** (Paraffin, Iso-paraffin, Olefin, Naphthene, Aromatic gas chromatography) - carried out on most LBPNs to provide quantitative information on these chemical functionalities present for each carbon number.
- **PAH** (Detailed poly-aromatic hydrocarbon analysis by high resolution gas chromatography-mass spectrometry) - carried out on all substances other than LBPNs (except for some heavy LBPNs) to provide information on the quantities of EPA and Grimmer PAHs present.
- **PAC-2** (Poly-cyclic aromatic carbon analysis by DMSO extraction and gas chromatography-mass spectrometry) - carried out on all substances other than LBPNs (except for some heavy LBPNs) to provide information on the total quantities of 1, 2, 3, 4, 5, 6, 7+ ring PACs present.
- **Elemental analysis** (C, H, N, O, S, As, Cd, Co, Cu, Fe, Mo, Ni, P, Pb, V, Zn, Cl, Hg, F) - carried out on all substances to provide information on the major elements and specific minor elements present.
- **FIMS** (Field ionisation mass spectrometry) - carried out on OLBOs and HRBO to provide quantitative information on the types of chemical functionalities present for each carbon number.
- **Spectroscopic analysis** - carried out on all substances to provide UV, IR, ^{1}H-NMR and ^{13}C-NMR spectra.
- **PCA** (Poly-cyclic aromatics analysis by DMSO extraction and gravimetric determination) - carried out on OLBOs and HRBO to provide quantitative information on the total quantity of 3+ ring PCAs present.
- **HPLC** - carried out on SRGOs, OGOs, VHGOs, CGOs, Kerosines, some heavy LBPNs, some light OLBOs and MK1 Diesel Fuel to provide quantitative information on the total quantities of mono-, di- and tri+ aromatics present.

- **TLC-FID** - carried out on Bitumens, Oxidised Asphalt, HFOs, Paraffin and Hydrocarbon Waxes, Foots Oils, Petrolatums, Slack Waxes, UATOs, TDAE, UDAEs, RAEs and VHGO to provide quantitative information on the basic chemical functionalities (saturates, aromatics, resins, asphaltenes) present.
- **LCC** (Liquid column chromatography) - carried out on Bitumen, Oxidised Asphalt, HFOs, Paraffin and Hydrocarbon Waxes, Foots Oils, OLBOs, HRBO, Petrolatums, Slack Waxes, UATOs, TDAE, UDAEs, RAEs, OGOs and VHGO to provide quantitative information on the basic chemical functionalities (saturates, aromatics, polars) present.
- **Viscosity measurement** - carried out on all substances (OLBOs, UATOs, HFOs, VHGOs) for which a viscosity statement is included in the formal substance description.

As shown in Section 1.1, some of these techniques were used to characterise samples in the 2013 AP, namely:

- **SIMDIS-GC** - carried out on SRGOs, OGOs, VHGOs, RAEs and Bitumens.
- **GCxGC** – carried out on SRGOs, OGOs and VHGOs.
- **HPLC** - carried out on SRGOs, OGOs and VHGOs.
- **PAH** - carried out on SRGOs, OGOs, VHGOs, RAEs and Bitumens.
- **PAC-2** - carried out on SRGOs, OGOs and VHGOs.
- **TLC-FID** - carried out on RAEs and Bitumens.

2. ANALYSIS OF SAMPLES

Laboratories in Europe and USA were involved in carrying out the analytical characterisation work on samples from the 2015 AP. Following agreement within the Concawe SIG on which procedures should be employed for characterisation, a Request for Proposal (RfP) was prepared for each procedure describing the work to be undertaken and the samples to be analysed. These RfPs were then circulated to several laboratories considered capable of undertaking the work together with invitations to submit detailed tenders should they wish to be considered as potential service providers. Tenders were reviewed by the Concawe Executive and the Project Coordinator who then made a recommendation to the SIG on which laboratories should be appointed to support the 2015 AP. Following approval by SIG, Concawe then prepared a formal contract with each laboratory involved in the program.

2.1. FIRST PHASE ANALYSIS OF SAMPLES

2.1.1. Physical Distillation

Physical distillation was carried out on the LBPN and Kerosine samples to provide information on the boiling range of these substances for comparison with the boiling range information provided in the formal substance descriptions shown in **Table 2**. Analysis was carried out according to ASTM D86 (36) by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK). **Appendix 2** shows an example report for Sample 019 (LBPN), and **Table 4** summarises the physical distillation results for all the samples analysed.

2.1.2. SIMDIS-GC

SIMDIS-GC was carried out on samples of all substances in the 2015 AP to provide information on the boiling and carbon number ranges of the components present for comparison with the corresponding information provided in the formal substance descriptions shown in **Table 2**. Some samples were analysed by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK) and others by ENI (ENI Downstream Laboratories, Milan, Italy). Different SIMDIS-GC methods were employed depending on the boiling range of the samples.

Analysis of the lighter substances was carried out by Intertek according to ASTM D7096 (37) and ASTM D2887 (38); Appendices 3 and 4 show example reports for Sample 023 (LBPN) and Sample 049 (Kerosine) respectively. ENI analysed the heavier substances according to ASTM D2887 (38) and EN 15199-2 (39), and Appendices 5 and 6 show example reports for Sample 121 (CGO) and Sample 058 (HFO) respectively. **Table 5** summarises the SIMDIS-GC results for all the samples analysed. The laboratories were requested to provide both the boiling point profiles and the carbon number distributions for the samples analysed, both data sets being relative to the boiling points of n-alkanes which were used to calibrate the SIMDIS-GC systems.

2.2. COMPARISON OF FIRST PHASE ANALYSIS RESULTS WITH FORMAL SUBSTANCE DESCRIPTIONS

As indicated in Section 1.2.1, the prime purpose of the first phase study was to determine whether the chemical compositions of the samples supplied were consistent with the formal substance descriptions, most of which are based on carbon number and/or boiling point ranges. To ensure objectivity in this assessment it was necessary to define the parameters used to judge whether a sample was representative of the registered substance, and **Figure 1** shows the decision tree that was developed for this purpose.

It was decided that ≥80% (m/m) should be used to quantify terms such as “mainly”, “predominantly” and “approximately” which are used extensively in the formal PS descriptions. It was also deemed appropriate to adjust the carbon number ranges given in the substance descriptions depending on the relative width of the carbon number range. As shown in **Figure 1**, adjustments of ±10% and ±20% were employed at different points in the decision tree to account for the fact that a substance with a wide carbon number range would be expected to exhibit greater variation at the limits of the range than a substance having a very narrow carbon number range. **Table 6** lists the ±10% and ±20% adjustments applied for the carbon number ranges defined in the formal substance descriptions.

For substances where both carbon number and boiling point ranges are defined in the substance description, the former was used to judge compliance based on SIMDIS-GC measurements being carried out on all substances whereas physical distillation was only performed on LBPN and Kerosine substances. For substances where neither of these parameters are defined but some other descriptor is given (e.g. viscosity), then compliance was based on the measured value being within ±10% of the defined value.

As shown in **Table 2**, some substances have no formal description, or the substance description is confusing or inconsistent. In such cases Concawe developed a substance description based on the substance name and the carbon number and boiling point ranges of similar materials in the same substance category.

Figure 1 shows that there are 9 possible outcomes when using the decision tree to determine whether the chemical compositions of the samples supplied were consistent with the formal substance descriptions: 4 outcomes denote acceptance (2, 6, 8, 9); 2 outcomes denote rejection (3, 4); and 3 outcomes denote review (1, 5, 7) signifying that the analytical data required further examination before making a final decision on acceptance or rejection.

Table 7 summarises the results obtained by applying the decision tree shown in **Figure 1** to the samples supplied for the 2015 AP.

2.3. SECOND PHASE ANALYSIS OF SAMPLES

Although Section 1.2.2 indicates the PS categories which were investigated using the procedures employed in the second phase analysis, it was not always possible to analyse every sample in a category by a specific method because the first phase analysis had shown that some samples were outside the scope of some methods.

2.3.1. GCxGC

GCxGC was carried out on most substances other than LBPNs to provide quantitative information on the types of chemical functionalities present for each carbon number. Analysis was carried out by Shell (Shell Technology Centre, Amsterdam, Netherlands). Samples containing components <C8 had to be analysed using a

combination of GCxGC and DHA-GC owing to the lower carbon number limit of the GCxGC technique; this enabled a comprehensive analysis of these samples to be carried out. Owing to the upper carbon number limit of GCxGC, only those components lighter than ~C30 could be determined in the heavier PS samples analysed and consequently these samples could not be comprehensively analysed. Samples which had been found by SIMDIS-GC to contain <5% (m/m) of <C30 components were not submitted for GCxGC analysis. **Table 8** summarises the GCxGC results for all the samples investigated.

2.3.2. DHA-GC

DHA-GC was carried out on most LBPNs to provide qualitative and quantitative information on the individual components present. Analysis was carried out according to ASTM D6730 (40) by ENI (ENI Downstream Laboratories, Milan, Italy). **Appendix 7** shows an example report for Sample 146, and **Table 9** summarises the DHA-GC results for all the samples analysed. In addition to reporting individual component data, the DHA-GC software grouped these data by summing the concentrations of n-paraffins, iso-paraffins, olefins, naphthenes and aromatics present to also provide the DHA-GC results in a PIONA-GC style format.

2.3.3. PIONA-GC

PIONA-GC was carried out by ENI on all the LBPN samples which they had analysed by DHA-GC (Section 2.3.2) to provide quantitative information on the different classes of hydrocarbons (naphthenes, paraffins, cyclic olefins, olefins, aromatics and oxygenates) present for each carbon number. Analysis was carried out according to EN 22854 (41) and, as shown in **Appendix 7**, the PIONA-GC results were included at the end of each sample report. **Table 10** summarises the PIONA-GC results for all the samples analysed.

2.3.4. PAH Analysis

PAH analysis was carried out on all substances other than LBPNs (except for some heavy LBPNs) to provide information on the quantities of EPA and Grimmer PAHs present. Some 32 individual PAHs were determined ranging from naphthalene (2-rings) to coronene (7-rings). Analysis was carried out by BIU (Biochemical Institute for Environmental Carcinogens, Hamburg, Germany) using proprietary methodology based on high resolution GC-MS with selective ion monitoring and deuterated internal standards for quantification (42). **Appendix 8** shows an example report for Sample 176 (VHGO), and **Table 11** summarises the PAH results for all the samples analysed.

2.3.5. PAC-2 Analysis

PAC-2 analysis was carried out on all substances other than LBPNs (except for some heavy LBPNs) to provide information on the total quantities of 1, 2, 3, 4, 5, 6, 7+ ring PACs present. Analysis was carried out by Port Royal Research (Hilton Head, South Carolina, USA) using proprietary methodology developed by Mobil which involved DMSO extraction and GC-MS analysis (34). Naphthalene, phenanthrene, benz[a]anthracene, benzo[a]pyrene, benzo[ghi]perylene and coronene were employed as retention markers for the unresolved 1, 2, 3, 4, 5, 6, 7+ ring PAC compounds present. Quantification was carried out by measuring the total peak areas between the retention marker boundaries and applying response factors obtained from the retention markers to the corresponding classes of PAC compounds. **Table 12** summarises the PAC-2 results for all the samples analysed.

2.3.6. Elemental Analysis

Elemental analysis was carried out on all substances to provide information on the concentrations of carbon, hydrogen, nitrogen, oxygen, sulphur, arsenic, cadmium, cobalt, copper, iron, molybdenum, nickel, phosphorus, lead, vanadium, zinc, chlorine, mercury and fluorine present. Analysis was carried out by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK) using several methods for the different elements measured. The carbon, hydrogen and nitrogen content were determined using a combustion analyser according to a modified version of ASTM D5291 (43); oxygen was measured by pyrolysis using an oxygen analyser; sulphur was measured by wavelength dispersive X-ray fluorescence spectrometry (WD-XRF) for higher sulphur concentrations (≥0.001% m/m), and by UV fluorescence (UVF) according to ASTM D5453 (44) for lower sulphur concentrations (≤0.001% m/m); chlorine was determined by monochromatic wavelength dispersive X-ray fluorescence spectrometry (MWD-XRF) according to ASTM D7536 (45); mercury was measured using cold vapor atomic absorption spectrometry (CVAAS) according to IP 594 (46); fluorine was measured by combustion and ion chromatography according to ASTM D7539 (47); the remaining elements were all determined using inductively coupled plasma – optical emission spectrometry (ICP-OES). **Appendix 9** shows an example report for Sample 190 (Bitumen), and **Table 13** summarises the elemental analysis results for all the samples analysed.

2.3.7. FIMS

FIMS was carried out on all OLBOs and a HRBO to provide quantitative information on the different classes of saturated hydrocarbons (acyclic alkanes; mono-, bi-, tri-, tetra-, penta-, hexa-cycloalkanes) and aromatic hydrocarbons (alkyl benzenes; indanes; indenes; naphthalenes/dibenzothiophenes; acenaphthenes/bi-phenyls; acenaphthylenes/fluorenes; phenanthrenes; benzothiophenes; fluoranthenes/pyrenes; benzanthracenes/chrysenes) present for each carbon number. Analysis was carried out by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK) and involved an initial HPLC separation of the oil samples into saturate and aromatic fractions according to IP 368 (48) followed by FIMS analysis of each fraction. The saturate fraction was also examined by GC according to IP 480 (49) to determine the quantities of normal and branched acyclic alkanes present. **Appendix 10** shows an example report for Sample 115 (OLBO), and **Table 15** summarises the FIMS results for all the samples investigated. It should be noted that some samples (118, 119, 145, 153, 154) only consisted of saturated components and consequently for these samples there was no aromatic fraction on which to carry out FIMS analysis.

2.3.8. Spectroscopic Analysis

Spectroscopic analysis was carried out on all substances to provide UV, IR, ^{1}H-NMR and ^{13}C-NMR spectra on each sample supplied. Analysis was carried out by Kuwait Petroleum (Kuwait Petroleum Research and Technology, Europoort, Netherlands) and **Appendix 11(a-d)** shows example spectra for the following samples: 043 (Kerosine); 129 (HFO); 145 (HRBO); Sample X. In addition to the spectral images, raw spectral data (e.g. wavenumber *vs*. intensity) were provided as Excel files to facilitate multi-variate statistical examination of the data to see whether correlations might exist between spectral information and PS categories.

2.3.9. PCA Analysis

PCA analysis was carried out on OLBOs, TDAE, UDAEs, Foots Oils, Petrolatums, RAEs and HRBO to provide quantitative information on the total quantity of 3+ ring PCAs present. Analysis was carried out according to IP 346 (35) by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK). **Appendix 12** shows an example report for Sample 075 (OLBO), and **Table 17** summarises the PCA results for all the samples analysed.

2.3.10. HPLC

HPLC was carried out on LBPN, Kerosine, SRGO, OGO, VHGO, CGO, Mk1 Diesel Fuel, OLBO and HFO samples, which had been selected to be within the scope of the method, to provide quantitative information on the total quantities of mono-, di- and tri+ aromatics present. Analysis was performed according to IP 548 (50) by Intertek (ITS Testing Services UK Ltd, Sunbury-on-Thames, UK). **Appendix 13** shows an example report for Sample 003 (CGO), and **Table 18** summarises the HPLC results for all the samples analysed.

2.3.11. TLC-FID

TLC-FID was carried out on Bitumens, Oxidised Asphalt, HFOs, Paraffin and Hydrocarbon Waxes, UATOs, TDAEs, UDAEs, Foots Oils, Petrolatums, Slack Waxes, RAEs and a VHGO to provide quantitative information on the basic chemical functionalities (saturates, aromatics, resins, asphaltenes) present. Analysis was carried out according to IP 469 (51) by Nynas (Nynas AB, Nynäshamn, Sweden). **Appendix 14** shows an example report for Sample 007 (HFO), and **Table 20** summarises the TLC-FID results for all the samples analysed.

2.3.12. LCC

LCC was carried out on Bitumens, Oxidised Asphalt, HFOs, Paraffin and Hydrocarbon Waxes, UATOs, TDAEs, UDAEs, Foots Oils, Petrolatums, Slack Waxes, RAEs, OLBOs, HRBO, OGOs and a VHGO to provide quantitative information on the basic chemical functionalities (saturates, aromatics and polars) present. Analysis was carried out according to ASTM D2007 (52) by Kuwait Petroleum (Kuwait Petroleum Research and Technology, Europoort, Netherlands). **Table 21** summarises the LCC results for all the samples analysed.

2.3.13. Viscosity

Viscosity measurements were carried out on all those substances (mainly OLBOs) for which a viscosity statement is included in the formal substance description. Analysis was carried out according to ASTM D445 (53) and ASTM D2161 (54) by SGS (SGS UK Ltd, Ellesmere Port, UK). **Appendix 15** shows an example report for Sample 182 (VHGO), and **Table 23** summarises the viscosity results for all the samples analysed.

2.4. SAMPLES ANALYSED BY REGISTRANTS

As indicated in Section 1.2, some LBPN substances were not supplied by the registrants owing to their concerns over safe transportation of the samples to the Sample Coordination Laboratory. These substances were therefore analysed in their own laboratories and the results sent to Concawe. Although the Project Coordinator provided information to these registrants on the suite of analyses which Concawe would like carried out, more limited dossiers of results were supplied. The samples analysed by the registrants are listed below together with a summary of the data supplied:

- **Sample 032:** The registrant provided SIMDIS-GC and DHA-GC data on 11 different samples of this substance originating from 4 different legal entities, and spectroscopic data (UV, IR, ^{1}H-NMR) on a single sample from each entity. Because the SIMDIS-GC data only provided information on the boiling point distribution (not the carbon number distribution) of the 11 samples and did not show the initial boiling point or the boiling point profile for the lighter components present, the entries shown in **Table 5** were compiled from the DHA-GC data.
- **Sample 159:** The registrant provided SIMDIS-GC and DHA-GC data on this sample. Because the SIMDIS-GC data only provided information on the boiling point distribution (not the carbon number distribution) of this sample, the entries shown in **Table 5** were compiled from the DHA-GC data.
- **Sample 167:** The registrant provided SIMDIS-GC and Physical Distillation data on this sample, but the SIMDIS-GC data only provided information on the boiling point distribution (not the carbon number distribution). Consequently only the carbon number range (estimated from the boiling point range) is shown in **Table 5**.
- **Naphtha 12:** The registrant only provided a DHA-GC raw data file on this sample, and consequently only the carbon number range (not the carbon number distribution) is shown in **Table 5**.
- **Sample 198:** The registrant only provided DHA-GC and PIONA-GC data on 4 different samples of this substance, and consequently the entries shown in **Table 5** were compiled from the DHA-GC results.
- **Naphtha 13:** The registrant only provided DHA-GC and PIONA-GC data on 4 different samples of this substance, and consequently the entries shown in **Table 5** were compiled from the DHA-GC results.

3. RESULTS AND DISCUSSION

3.1. COMPARISON OF RESULTS FROM 2013 AND 2015 ANALYTICAL PROGRAMS

As indicated in Section 1.2, 19 sub-samples of SRGO, OGO, VHGO and RAE samples from the 2013 AP were transferred to the 2015 AP to provide a comprehensive sample set covering all active registered PS in the 20 substance categories. In the 2013 AP the SRGO, OGO, VHGO samples had been analysed by SIMDIS-GC, GCxGC, HPLC, PAH analysis and PAC-2 analysis; and the RAE samples by SIMDIS-GC, TLC-FID and PAH analysis. These samples were analysed alongside other samples of registered PS during the 2015 AP using both the techniques employed in the 2013 AP and other techniques as described in Section 2.3. It was therefore possible to compare the results generated on the same samples before and after a two-year storage period. SIMDIS-GC, GCxGC, HPLC and TLC-FID analyses were carried out by different laboratories in the 2013 and 2015 programs whereas PAH analysis and PAC-2 analysis were carried out by the same laboratory for both studies.

3.1.1. SIMDIS-GC

Comparison of the boiling point distributions obtained by SIMDIS-GC and previously reported for the 2013 AP (4-6, 8, 10, 12, 14, 16-21, 23-26, 32, 33) and summarised in **Table 5** for the 2015 AP show good agreement between the results obtained on the same samples despite the analyses having been carried out by different laboratories using different SIMDIS-GC software systems and on samples which had been stored for approximately two years.

3.1.2. GCxGC

GCxGC analysis on the same samples was only carried out on Samples 173 (CON 7) and 176 (CON 13), the results of which have been previously reported for the 2013 AP (12, 17) and are shown in **Table 8** for the 2015 AP. Relatively good agreement was obtained between the two sets of results for Sample 173 (CON 7) but Sample 176 (CON 13) showed poorer agreement, possibly owing to the presence of heavier (>C30) components in this sample which are not amenable to GCxGC.

3.1.3. HPLC

Comparison of the mono-, di- and tri+ aromatic contents obtained by HPLC and previously reported for the 2013 AP (4-6, 8, 10, 12, 14, 16-21, 23, 24, 26) and summarised in **Table 18** for the 2015 AP show good overall agreement between the results obtained given that the analyses were carried out by different laboratories on samples which had been stored for approximately two years.

3.1.4. TLC-FID

Good agreement was obtained between the TLC-FID results for the two RAE substances, Samples 185 (CON 26) and 186 (CON 27), analysed in the 2013 and 2015 programs given that the analyses were carried out by different laboratories on samples which had been stored for approximately two years. Both samples contained an “unknown” peak in the 2013 AP (32, 33) which eluted between the saturate and aromatic peaks and most probably arose from partially hydrogenated aromatic components (e.g. naphthenic aromatic hydrocarbons). In the 2015 AP results, which are summarised in **Table 20**, this peak was included with the aromatic components and consequently the “unknown” peak in the 2013 AP results has been included with the aromatic components when comparing the results from both programs.

3.1.5. PAH Analysis

The 2013 AP involved measurement of 28 individual PAHs in SRGO (4-6, 8, 10), OGO (12, 14), VHGO (16-21, 23-26) and RAE (32, 33) samples but, as shown in **Table 11**, this was extended to cover 32 individual PAHs in the 2015 AP. Comparison of the results obtained from both studies for the corresponding PAHs in the same samples showed very good agreement, especially considering that this involved the trace level analysis of individual chemical components in relatively complex sample matrices. The only discrepancies in results were found for Sample 169 (CON 2) which, given the very good results agreement obtained for the other 18 samples, suggests that an error was made by the Sample Coordination Laboratory or the Analytical Laboratory in the handling and/or labelling of this sample.

3.1.6. PAC-2 Analysis

Good agreement was obtained between the results obtained by PAC-2 analysis for all the SRGO, OGO and VHGO samples examined in the 2013 AP (4-6, 8, 10, 12, 14, 16-21, 23-26) and the 2015 AP (**Table 12**). Some minor discrepancies for 1-ring and 2-ring PACs were observed but this is not surprising because, as indicated in Section 1.1, these lighter aromatic compounds are not quantitatively removed by the DMSO extraction employed in the PAC-2 procedure.

3.2. RESULTS FROM 2015 ANALYTICAL PROGRAM

3.2.1. SIMDIS-GC

As discussed in Section 2.2, carbon number ranges obtained by SIMDIS-GC (**Table 5**) were used to judge whether the supplied samples were representative of the registered PS based on the formal substance descriptions. As shown by the shaded areas (yellow) and the summation values (red) in **Table 5**, for the great majority of samples examined ≥80% (m/m) of the components present were within the defined carbon number ranges.

For the 218 samples listed in **Table 5**:

- 179 samples have ≥80% (m/m) of components within the defined carbon number range.
- 17 samples have ≤80% (m/m) of components within the defined carbon number range (Naphtha 1; CGO 1; Naphtha 5; 042; Naphtha 7; 067; 068; 080; 094; 098B; 107; Kero 4; 141; 163; 177; 188; 198-R21) although 4 of these samples (CGO 1; 098B; 141; 188) are borderline in having ≥79% (m/m) of components within the defined range. Moreover, PIONA-GC showed that a further 3 samples (Naphtha 1; 042; 094) actually contained ≥80% (m/m) of components within the defined range when examined using this technique. SIMDIS-GC measures carbon number distribution using n-alkanes as retention calibrants and consequently, as illustrated in **Figure 2**, significant discrepancies can arise with samples containing large concentrations of other hydrocarbon functionalities such as 042 and 094, which consist almost entirely of aromatic hydrocarbons.
- 22 samples have no defined carbon number range (014; OLBO 1; CGO 2; 053; 078; 079; 091; Naphtha 9; Naphtha 10; 129; 131; 171; 181; 182; 183; 183R; 193; 193X; Naphtha 13).

Although some 93% of samples with a defined carbon number range had ≥80% (m/m) of components within this range, it was considered important to also take account of the carbon number distribution within the defined range when assessing how well the composition of each sample agreed with the formal substance description. For example, it could be argued that a sample which only contains C9-C10 components is not representative of a substance with a defined range of C6-C15 despite having 100% of the components within the defined carbon number range.

The decision tree depicted in **Figure 1** takes account of the measured carbon number distribution, or other measured properties (e.g. boiling point range; viscosity) for those substances with no defined carbon number range. As shown, there are 9 possible outcomes when assessing whether the measured composition is consistent with the formal substance description. The results obtained by applying the decision tree to each sample supplied for the 2015 AP are shown in **Table 5**, and **Table 7** provides a summary of these results (including the excluded samples).

For the samples listed in **Table 5**:

- 101 samples met one of the 4 *"Accept"* criteria [② ⑥ ⑧ ⑨] defined by the decision tree.

- 107 samples met one of the 3 *"Review"* criteria [① ⑤ ⑦] defined by the decision tree, 89 being classified as *"Review* ⑤*"* because the carbon number distribution was narrower than that defined in the formal substance description (≤1% (m/m) of components present at the upper and/or lower carbon number range).

- 7 samples met one of the 2 *"Reject"* criteria [③ ④] defined by the decision tree, 6 of which were classified as *"Reject* ③*"*. These samples (Naphtha 5; 067; 080; 107; 163; 177) only contained 40-68% (m/m) of the components defined in the formal substance descriptions. The remaining sample (OLBO 1) was only defined by viscosity, and it was rejected because the measured viscosity was much higher than that defined in the formal substance description.

Although the first phase analysis of samples was originally planned as a screening process to identify samples which were not representative of the registered substance and would not therefore proceed to the more detailed second phase analysis, it was found that only a small number of samples were rejected because SIG decided that, despite some samples being reviewed owing to their carbon number distribution, all samples with ≥80% (m/m) of components within the defined carbon number range should proceed to second phase analysis. Moreover, there were significant delays in the supply of samples from some registrants and, to avoid delays in commencing the second phase studies and promote efficiency in the preparation and despatch of samples by the Sample Coordination Laboratory, virtually all samples proceeded to second phase of program.

3.2.2. Physical Distillation

The physical distillation results obtained on the LBPN and Kerosine samples are presented in **Table 4** alongside the substance descriptions. From a subjective analysis of the data approximately 40% of the measured boiling point ranges were in relatively good agreement with the values given in the formal substance descriptions. Clearly several LBPN descriptions refer to low initial boiling points (<10°C) which were beyond the scope of the physical distillation procedure (36) employed in this study.

As might be expected for those samples where the physical distillation results and substance descriptions were in good agreement, comparison with the results of the decision tree analysis described in Section 3.2.1 showed that the vast majority of these samples met the *"Accept* ⑨*"* criterion. A few samples met the *"Review* ⑤*"* criterion owing to the absence (i.e. ≤1% (m/m)) of the lower range components; and Naphtha 5, which has a very narrow carbon number range definition, met the *"Reject* ③*"* criterion despite the good agreement between physical distillation data and the substance description.

Most of the samples where the physical distillation results showed poor agreement with the substance descriptions met the *"Review* ⑤*"* criterion, although a few met the *"Review* ⑦*"* criterion owing to large discrepancies between measured and defined final boiling points.

3.2.3. GCxGC

Although only substances containing components in the ~C8-C30 range can be comprehensively examined by GCxGC, making it best suited to the analysis of middle-distillate substances such as kerosines and the lighter gas oils, this technique was applied to a wide range of PS in the 2015 AP including CGO, HFO, Kerosine, OLBO, MK1 Diesel Fuel, Paraffin and Hydrocarbon Wax, UATO, TDAE, UDAE, Foots Oil, Petrolatum, Slack Wax, HRBO, SRGO, OGO, VHGO, Oxidised Asphalt and some heavy LBPN samples.

Table 24 provides a summary of the samples analysed in the 2015 AP and the detailed GCxGC results for each sample are presented in **Table 8**. As described in Section 1.1, GCxGC results on those samples which were transferred from the 2013 AP have been previously reported (4-26), and the results tables from these reports are shown in **Appendix 1** for reference purposes.

As shown in **Table 24**, the proportion of each sample which was amenable to GCxGC analysis ranged from 6.3% (m/m) for Oxidised Asphalt to 100% (m/m) for the lighter PS, and the GCxGC recoveries obtained were in very good agreement with the corresponding SIMDIS-GC recoveries for <C31 components (except for Sample 127 where the SIMDIS-GC analysis should possibly be repeated). Because the heavy naphtha samples (Naphtha 7; 076; 141; 158) contained some <C8 components, which are too volatile for quantitative trapping in the GCxGC modulator, these samples were characterised using a combination of GCxGC and DHA-GC.

The detailed GCxGC results presented in **Table 8** are consistent with the anticipated composition of each sample analysed. For example: Paraffin and Hydrocarbon Wax (061; 062; 065) and Slack Wax (127; 136R; 152) samples contained a high proportion of n-paraffins; no significant concentrations of aromatic components were found in the HRBO sample (145); and the non-hydrotreated, catalytically cracked substances (008; 034; 106; 130; 155) contained high concentrations of aromatic hydrocarbons.

3.2.4. DHA-GC

All but the heavy LBPN samples were examined by DHA-GC and the results obtained are shown in **Table 9**. The data are presented as a list of the individual hydrocarbons found in the sample together with their concentrations. Although not shown in **Table 9**, the individual reports on each sample contain DHA-GC data where, in addition to reporting the concentration of each component present, the DHA-GC results have been grouped by summing the concentrations of n-paraffins, iso-paraffins, olefins, naphthenes and aromatics present to provide the DHA-GC results in a PIONA-GC format. These results showed good agreement with those obtained on the same samples using the PIONA-GC technique (see Section 2.3.3 and Section 3.2.5).

3.2.5. PIONA-GC

In addition to DHA-GC analysis, the LBPN samples were also examined by PIONA-GC and the results obtained are presented in **Table 10** (these results are also shown in **Table 5** alongside the SIMDIS-GC results on the corresponding samples). Whereas the DHA-GC results were grouped into n-paraffins, iso-paraffins, olefins, naphthenes and aromatics for presentation in a PIONA-GC format (see Section 2.3.2 and Section 3.2.4), the actual PIONA-GC results were grouped into naphthenes, paraffins, cyclic olefins, olefins, aromatics and oxygenates.

3.2.6. PAH Analysis

The detailed results on all samples analysed are shown in **Table 11**. Data are presented for each of the 32 individual PAHs determined together with the results obtained from grouping the individual PAHs by ring number. The samples in **Table 11** have also been grouped by category to facilitate comparison between different substances in the same category.

Given the vast difference in toxicity index between individual PAHs, a high total concentration of the 32 individual PAHs measured does not necessarily infer that these substances will exhibit the greatest toxicity. However, it is clear from the data presented in **Table 11** that virtually all substances in some categories, such as Paraffin and Hydrocarbon Waxes, Slack Waxes, Petrolatums and OLBOs, have very low total concentrations of the measured PAHs.

In contrast, the highest total concentrations were found in samples in the CGO (106; 130) and HFO (008; 034; 155) categories which contained between ~2% (m/m) and ~7% (m/m) of the measured PAHs. As described in Section 3.2.3, these are the same samples which were found to contain the highest concentrations of aromatic hydrocarbons when examined by GCxGC. The highest concentrations of the widely used PAH marker compound, benzo[a]pyrene, were found in two of these HFO samples: 008 (794 mg/kg) and 034 (1089 mg/kg).

3.2.7. PAC-2 Analysis

The PAC-2 Analysis results are presented in **Table 12**. Examination of the total mass extracted shows a good correlation with the highest total concentrations of individual PAHs reported in **Table 11** (Section 3.2.6); CGO samples (106; 130) and HFO samples (008; 034; 134; 155) yielded the highest quantities of DMSO extractables. Interestingly one of the LBPN samples examined (Naphtha 2) also provided a high total mass extracted (25%) but the profile for this sample shows that the extractable material consisted only of 1-ring and 2-ring PACs. As indicated in Section 1.1, these lighter aromatic compounds are not quantitatively removed by the DMSO extraction employed in the PAC-2 procedure, so the actual quantity of total aromatics present in this sample is likely to be significantly higher than that shown in **Table 12**; PIONA-GC showed that this sample actually contained 99.7% (m/m) total aromatics.

Examination of the PAC-2 profiles reported in **Table 12** shows that the highest concentrations of heavier PACs (4-7 ring components) are found in HFO samples. Samples 008 and 034 contained the highest quantities of 4-7 ring PACs from all the samples examined using the PAC-2 procedure and examination of the results obtained from grouping the individual PAHs by ring number (**Table 11**) shows that the same two samples have the highest concentrations of these heavier PAHs. In summary, it therefore appears that, despite employing different measurement principles, there is an excellent correlation between the data obtained by the PAH Analysis and PAC-2 Analysis procedures.

3.2.8. Elemental Analysis

Table 13 shows the elemental analysis results for all samples examined in the 2015 AP. As indicated in the table, a good mass balance for all samples was obtained from the summation of the measured concentrations of carbon, hydrogen, sulphur, nitrogen and oxygen. Carbon to hydrogen ratios were calculated for all the samples analysed and these are presented in **Table 14**, grouped by category. Because some of the categories listed in **Table 14** contain very few samples, some caution is required when interpreting these data. However, as expected the highest carbon to hydrogen ratios were found for those substances with relatively high aromatic contents (Bitumen; CGO; HFO; RAE; UDAE) and the lowest for those substances with higher paraffinic contents (Foots Oil; Paraffin and Hydrocarbon Wax; Petrolatum; Slack Wax).

Relatively low concentrations (≤0.7% m/m) of nitrogen and oxygen were found in those samples where these elements were detected with the exception of two of the six substances which have been excluded from this report which contained 1.0% (m/m) and 8.0% (m/m) oxygen. Manufacture of the latter substance involves an oxidation process which is consistent with the high measured oxygen content. The highest concentrations of sulphur (>2% m/m) were found in samples of Bitumen (189; 192); RAE (185; 186); UDAE (089; 096A; 096B); HFO (020; 021; 025; 031; 078; 080); UATO (064); and TDAE (069).

Most samples contained no measurable concentrations of the minor elements investigated (As, Cd, Co, Cu, Fe, Mo, Ni, P, Pb, V, Zn, Cl, Hg, F) although some HFO and Bitumen samples contained elevated levels of Fe, Ni and V, which occur naturally in crude oil and are typically bound up in the heavier residual fractions. The maximum measured concentrations of these elements were 48 mg/kg (Fe); 54 mg/kg (Ni); and 207 mg/kg (V). Interestingly, one LBPN sample (027) was found to have a high fluorine content (89 mg/kg) which, given that this is a full-range alkylate sample, presumably resulted from traces of organofluorides produced during the manufacturing process in which hydrofluoric acid is used as an alkylation catalyst.

3.2.9. FIMS

The detailed results on all 61 fractions of OLBO and HRBO samples examined by FIMS are presented in **Table 15**. As described in Section 2.3.7, OLBOs (118; 119; 153; 154) and the HRBO (145) only consisted of saturated components and consequently these samples only yielded 5 fractions. However, the remaining 28 OLBO samples could be separated into aromatic and saturated components and therefore yielded 56 fractions. Owing to the relative complexity of the data presented in **Table 15** and to facilitate comparison between samples, the 3D images showing the type and carbon number range of the components present are shown separately in **Table 16**.

3.2.10. Spectroscopic Analysis

Appendix 11(a-d) shows UV, IR, ^{1}H-NMR and ^{13}C-NMR spectra acquired on 4 samples, each from a different substance category and with diverse chemical compositions:

- Sample 043 – Kerosine *[Kerosine (petroleum)]*
- Sample 129 – HFO *[Residual oils (petroleum)]*
- Sample 145 – HRBO *[White mineral oil (petroleum)]*
- Sample X

Despite their diverse compositions, the IR spectra of 043, 129 and 145 are very similar with the major peaks in the 2800 – 3100 cm^{-1} region arising from various perturbations of the C-H bonds present. However, the IR spectrum of one substance (Sample X) which has been excluded from this report is significantly different exhibiting absorbance bands corresponding to C=O and C-O perturbations consistent with the high oxygen content found in this sample (see Section 3.2.8).

The UV spectra provide little useful information except that the spectrum of 145 was acquired on a neat sample of this substance whereas the other 3 samples all required high dilution with heptane (concentration range 13.8 – 234 mg/L) to produce on-scale spectra. This demonstrates the absence of aromatics and/or olefinic components in the HRBO sample because such components result in very strong absorbances at wavelengths below ~300 nm.

Examination of the ^{1}H-NMR spectra shows little difference in the region of main resonances (0.5 – 4.0 ppm) except that in 145 there are no resonances in the 2.0 – 4.0 ppm region from protons on groups adjacent to an aromatic ring, which indicates the absence of aromatics in this sample. This observation is vindicated by the absence of aromatic proton resonances in the 6.7 – 8.0 ppm region.

The ^{13}C-NMR spectra basically endorse the findings from the ^{1}H-NMR spectra because no resonances arising from aromatic carbons could be detected in the 120 – 150 ppm region for the HRBO sample (145).

In summary, spectroscopic analysis of petroleum UVCB substances can provide evidence on the composition of those substances with very specific chemical properties (e.g. absence of aromatic components; presence of large concentration of carboxylic acids). However, the great majority of PS cannot be effectively differentiated from each other by UV, IR, ^{1}H-NMR or ^{13}C-NMR spectroscopic analysis, and the results from the 2015 AP endorse the previously expressed view from Concawe (1) that spectroscopic analysis provides no additional information to that obtained by the other techniques recommended to member companies for generating compositional information on their products (2, 3).

3.2.11. PCA Analysis

Table 17 provides a summary of the PCA results for the OLBO, TDAE, UDAE, Foots Oil, Petrolatum, RAE and HRBO samples examined in the 2015 AP. As indicated, some samples were not amenable to the IP 346 (35) method because they could not be completely dissolved in cyclohexane which is used to solubilise the samples prior to extraction of the PAC components with DMSO.

The great majority of OLBOs had low PCA contents (<1% m/m) which is to be expected given that the product specification for finished oils requires the PCA content to be <3% (m/m) when measured by IP 346. The highest PCA content for OLBOs (5.1% m/m) was found in OLBO 1; five other samples (074; 075; 081; OLBO 6; 140) had PCA contents in the 1-2% (m/m) range. Not surprisingly, all the aromatic extracts (TDAE, UDAE, RAE) had relatively high PCA contents with the UDAE samples (089; 096A; 096B) producing the highest values (range 10.5 – 28.5% (m/m)).

Comparison of the PCA results in **Table 17** with the PAC-2 total mass extracted results reported in **Table 12** shows a good correlation between these data sets although the values reported using the PAC-2 procedure are generally ~50% of those obtained with the IP 346 method. This is not surprising given the slight differences in these two procedures and knowledge gained during the development and routine use of the IP 346 method which has shown that strict control of laboratory procedures is required to obtain reproducible results.

3.2.12. HPLC

The total quantities of mono-, di- and tri+ aromatics present in the LBPN, Kerosine, SRGO, OGO, VHGO, CGO, Mk1 Diesel Fuel and OLBO samples analysed by HPLC (IP 548) are presented in **Table 18**. As shown, some of the samples which were submitted for analysis were not amenable to the method, but subsequent analysis of these samples by GCxGC indicated that their chemical composition was somewhat different from the composition of the diesel fuels and blending components for which IP 548 was originally developed.

Not surprisingly, mono-aromatic components accounted for the great majority of aromatics present in the LBPN and Kerosine samples analysed. Only the heavier LBPN samples were analysed by HPLC and the substance descriptions of those samples (Naphtha 2; 054; 101; 146) which contained >50% (m/m) total aromatics show that these samples are expected to have a high aromatic content. The highest concentration of total aromatics found in the Kerosine samples was 23.1% (m/m) for Kero 4; and the lowest was 0.2% (m/m) for Kero 1 which is a hydrotreated, dearomatized substance. In general, the gas oil (SRGO, OGO, VHGO, CGO) samples had the highest concentrations of poly-aromatic hydrocarbons (di- and tri+ aromatics) and, in contrast with all the samples from the other substance categories which contained ≤0.4% (m/m) tri+ aromatics, all but one of the gas oil samples had much higher tri+ aromatic contents. As described in Section 2.3.7, two OLBO samples (118; 119) only consisted of saturated components which is endorsed by the HPLC results presented in **Table 18** which show very low aromatic contents for these two samples. As expected, the Mk1 Diesel Fuel (Sample 059) only contained 4.2% (m/m) total aromatics.

Table 19 presents the results obtained by HPLC (IP 548) together with the GCxGC results from the corresponding samples obtained during the 2013 and 2015 Analytical Programs. Because GCxGC gives a higher level of granularity for chemical functionalities than the IP 548 procedure, it was necessary to aggregate some of the GCxGC data (e.g. mono-aromatics + naphthenic mono-aromatics) to obtain equivalent data (e.g. mono-aromatics) to those generated by HPLC. Good agreement between the HPLC and GCxGC results was obtained for the great majority of samples, especially considering the vast difference in the principles of the two procedures. The only major discrepancy was found for Sample 074 (OLBO), which is unexplained therefore requires further investigation. The two OLBO samples referred to above (118; 119) were found to contain low levels of aromatics by GCxGC but, as indicated in **Tables 18** and **19**, the mono-aromatic results for the HPLC analysis fall outside the precision range for this procedure and the refractive index detection system employed in the IP 548 method is not particularly good for low concentration measurements.

3.2.13. TLC-FID

Table 20 shows the quantities of saturates, aromatics, resins and asphaltenes found in the Bitumen, Oxidised Asphalt, HFO, Paraffin and Hydrocarbon Wax, UATO, TDAE, UDAE, Foots Oils, Petrolatum, Slack Wax, RAE and VHGO samples analysed by TLC-FID (IP 469). Although this technique is very good at quantifying the basic chemical functionalities (saturates, aromatics, resins, asphaltenes) in very complex PS, strict control of the experimental conditions and especially the matching and uniform conditioning of the TLC silica rods is essential to achieve good results. The analytical laboratory therefore employed a system standard in every batch of samples analysed and the data presented in **Table 20** illustrate the relatively good reproducibility of the system standard results obtained. Moreover and in accordance with IP 469, samples were analysed in triplicate and the results presented in

Table 20 are the mean values obtained from the three analyses carried out on each sample.

3.2.14. LCC

The concentrations of saturates, aromatics and polars measured in the Bitumen, Oxidised Asphalt, HFO, Paraffin and Hydrocarbon Wax, UATO, TDAE, UDAE, Foots Oil, Petrolatum, Slack Wax, RAE, OLBO, HRBO, OGO and VHGO samples analysed by LCC (ASTM D2007) are presented in **Table 21**. As shown, good recoveries (> 98% m/m) were obtained for the great majority of samples; Sample 189 (Bitumen) and Sample 193 (Oxidised Asphalt) gave recoveries of 90.3% (m/m) and 93.2% (m/m) respectively but both these samples contained high concentrations of asphaltenes which were removed by precipitation prior to the LCC procedure so this could account for the lower recoveries obtained for these two samples.

As shown in **Table 22**, the LCC results are in relatively good agreement with the TLC-FID results for those samples which were analysed by both of these techniques.

3.2.15. Viscosity

Viscosity data obtained on the OLBO, UATO, HFO and VHGO samples analysed are shown in **Table 23** together with the viscosity values given in the formal substance descriptions. In most cases the measured viscosity is consistent with the quoted value although, as highlighted in **Table 23**, significant discrepancies were found for Samples OLBO 1, 118, 119, 147, 148, 151.

4. CONCLUSIONS

4.1. COMPARISON OF RESULTS FROM 2013 AND 2015 ANALYTICAL PROGRAMS

Many of the SRGO, OGO, VHGO and RAE samples which had been examined in the 2013 AP and then transferred to the 2015 AP were re-analysed by SIMDIS-GC, HPLC, and TLC-FID using different analytical laboratories, and by PAH and PAC-2 analysis using the same laboratories. It was therefore possible to compare the results generated on the same samples before and after a two-year storage period.

The boiling point distributions obtained by SIMDIS-GC from both studies showed good agreement despite the analyses having been carried out by different laboratories using different SIMDIS-GC software systems and on samples which had been stored for approximately two years. The mono-, di- and tri+ aromatic contents obtained by HPLC in the 2015 AP also showed good overall agreement with the results generated on the same samples in the 2013 AP. Good agreement was also obtained between the TLC-FID results for the two RAE substances examined in both programs.

Although the suite of PAHs examined in the 2015 AP was slightly larger than in the 2013 AP, comparison of the results from both studies for the corresponding PAHs in the same samples showed very good agreement, especially considering that this involved the trace level analysis of individual chemical components in complex sample matrices. Good agreement was also obtained between the PAC-2 analysis results from both programs.

In summary, it can therefore be concluded that the integrity of those samples examined was maintained over a two-year storage period and that the analytical procedures employed exhibited good reproducibility.

4.2. RESULTS FROM 2015 ANALYTICAL PROGRAM

The great majority (93%) of samples with a defined carbon number range in the formal substance description were found to contain ≥80% (m/m) of components within this range, and consequently only a small number of samples did not proceed to the more detailed second phase analysis, which involved a variety of analytical techniques as listed in Section 1.2.2.

Although only substances containing components in the ~C8-C30 range can be comprehensively examined by GCxGC, making it best suited to the analysis of middle-distillate substances such as kerosines and the lighter gas oils, this technique was applied to many other types of substances in the 2015 AP including HFO, OLBO, Paraffin and Hydrocarbon Wax, UATO, TDAE, UDAE, Foots Oil, Petrolatum, Slack Wax, HRBO and Oxidised Asphalt. Clearly the proportion of each sample which was amenable to GCxGC analysis varied depending on the boiling range of the material (e.g. 6.3% (m/m) for Oxidised Asphalt to 100% (m/m) for Kerosine), but the GCxGC recoveries obtained were in very good agreement with the corresponding SIMDIS-GC recoveries for <C31 components throughout the range of substances examined. The GCxGC results were also consistent with the anticipated composition of each sample analysed: Paraffin and Hydrocarbon Wax and Slack Wax samples contained a high proportion of n-paraffins; no significant concentrations of aromatic components were found in the HRBO sample; and the non-hydrotreated, catalytically cracked substances contained high concentrations of aromatic hydrocarbons. Results obtained on the great majority of samples which were amenable to both GCxGC analysis and HPLC measurement of mono-, di- and tri+ aromatics showed good agreement, especially given the vast difference in measurement principles between these two procedures.

For the LBPN samples, DHA-GC results were grouped by summing the individual concentrations of n-paraffins, iso-paraffins, olefins, naphthenes and aromatics present to provide data in an equivalent format to that generated by the PIONA-GC technique. Comparison of these results with those obtained by direct analysis of the same samples using PIONA-GC showed good agreement between the two sets of data.

Not surprisingly, virtually all substances in the Paraffin and Hydrocarbon Waxes, Slack Waxes, Petrolatums and OLBO categories had very low total concentrations of the individual PAHs measured whereas the highest total concentrations were found in CGO and HFO samples. Samples which yielded the highest quantities of DMSO extractables by PAC-2 Analysis were also found to contain the highest total concentrations of individual PAHs showing that, despite employing different measurement principles, there is a good correlation between data obtained by the PAH Analysis and PAC-2 Analysis procedures.

Elemental analysis confirmed that the highest carbon to hydrogen ratios are found in those substances with relatively high aromatic contents (Bitumens; CGO; HFO; RAE; UDAE) and the lowest in those substances with higher paraffinic contents (Foots Oils; Paraffin and Hydrocarbon Waxes; Petrolatums; Slack Waxes). Most samples contained no measurable concentrations of the minor elements investigated (As, Cd, Co, Cu, Fe, Mo, Ni, P, Pb, V, Zn, Cl, Hg, F) although some HFO and Bitumen samples contained elevated levels of Fe, Ni and V, which occur naturally in crude oil and are typically bound up in the heavier residual fractions.

LCC results were in relatively good agreement with the TLC-FID results for those samples which were analysed by both techniques.

Spectroscopic examination of all samples in the 2015 AP showed that useful compositional information was only provided for two substances: (i) to show the absence of aromatic components; (ii) to show the presence of a large concentration of carboxylic acids. The great majority of PS cannot be effectively differentiated from each other by UV, IR, ^{1}H-NMR or ^{13}C-NMR spectroscopic analysis, which endorses the SIG view that spectral data generally provide no useful additional information for substance identification to that obtained using chromatographic techniques.

In summary, it can be concluded that with few exceptions the chemical compositions of the samples analysed were consistent with their formal substance descriptions, and that the results generated for the same measurands using different analytical techniques showed good agreement.

5. GLOSSARY

CGO	Cracked Gas Oils
HFO	Heavy Fuel Oils
HRBO	Highly Refined Base Oils
LBPN	Low Boiling Point Naphthas
OGO	Other Gas Oils
OLBO	Other Lubricant Base Oils
RAE	Residual Aromatic Extracts
SRGO	Straight-Run Gas Oils
TDAE	Treated Distillate Aromatic Extracts
UATO	Unrefined / Acid Treated Oils
UDAE	Untreated Distillate Aromatic Extracts
VHGO	Vacuum Gas Oils, Hydrocracked Gas Oils and Distillate Fuels
AP	Analytical Program
DHA-GC	Detailed Hydrocarbon Analysis - Gas Chromatography
ECHA	European Chemicals Agency
FIMS	Field Ionisation Mass Spectrometry
GCxGC	Comprehensive Two-Dimensional Gas Chromatography
GC-MS	Gas Chromatography - Mass Spectrometry
HPLC	High Performance Liquid Chromatography
IR	Infra-Red
IUCLID	International Uniform Chemical Information Database
LCC	Liquid Column Chromatography
NMR	Nuclear Magnetic Resonance
PAC	Poly-cyclic Aromatic Carbons
PAH	Poly-Aromatic Hydrocarbons
PCA	Poly-Cyclic Aromatics
PIONA-GC	Paraffin, Iso-paraffin, Olefin, Naphthene, Aromatic - Gas Chromatography
PS	Petroleum Substance(s)
REACH	Registration, Evaluation and Authorisation of Chemicals
RfP	Request for Proposal
SIG	Substance Identification Group
SIMDIS-GC	Simulated Distillation - Gas Chromatography
TLC-FID	Thin Layer Chromatography - Flame Ionisation Detection
UV	Ultra-Violet
UVCB	Unknown or Variable composition, Complex reaction products or Biological materials

6. ACKNOWLEDGEMENTS

The Concawe Substance Identity Group thanks all companies that kindly provided samples for the 2015 Analytical Program.

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Figure 1 - Decision Tree employed in First Phase of 2015 Analytical Program

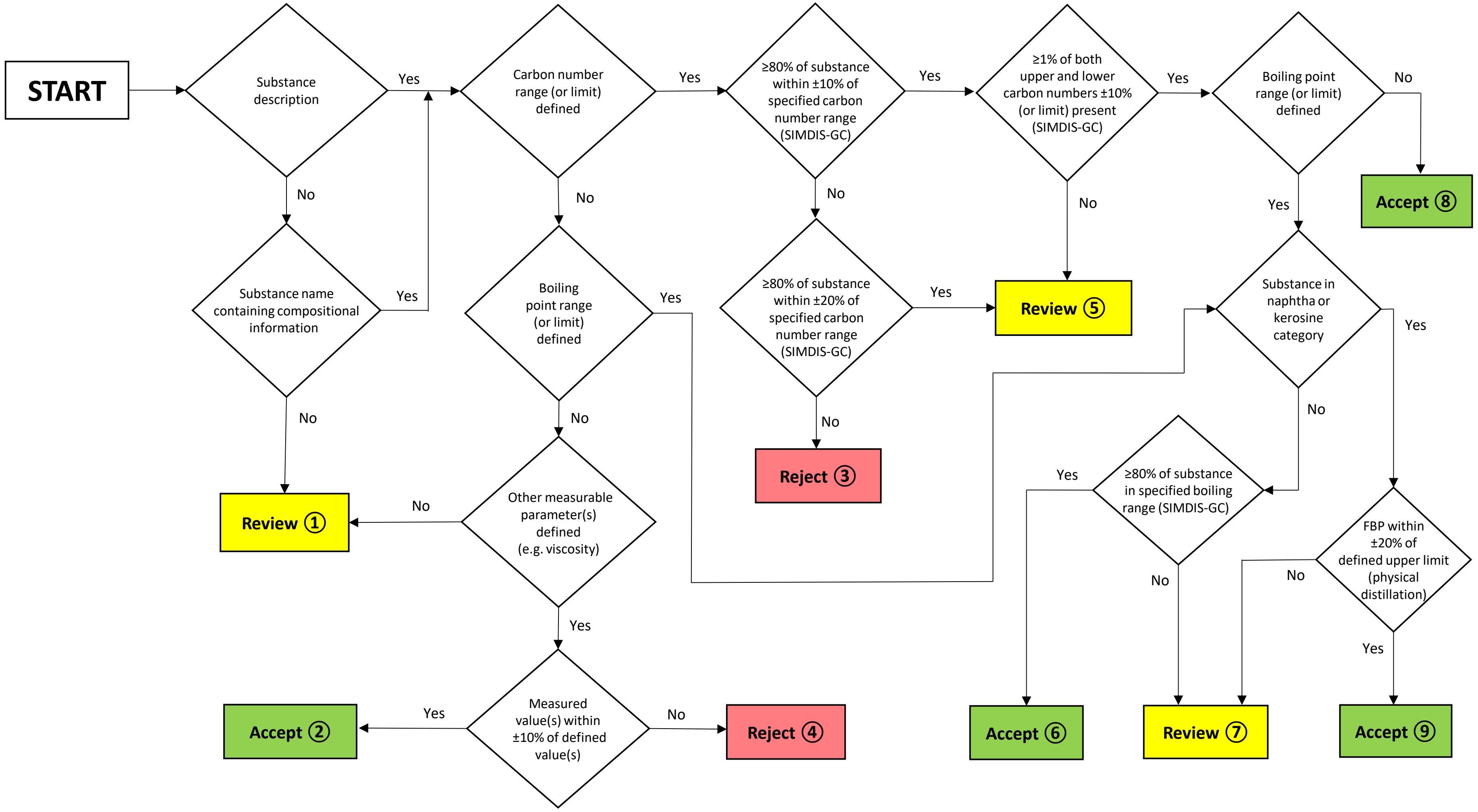


Figure 2 - Relationship between volatility and carbon number for different hydrocarbon functionalities

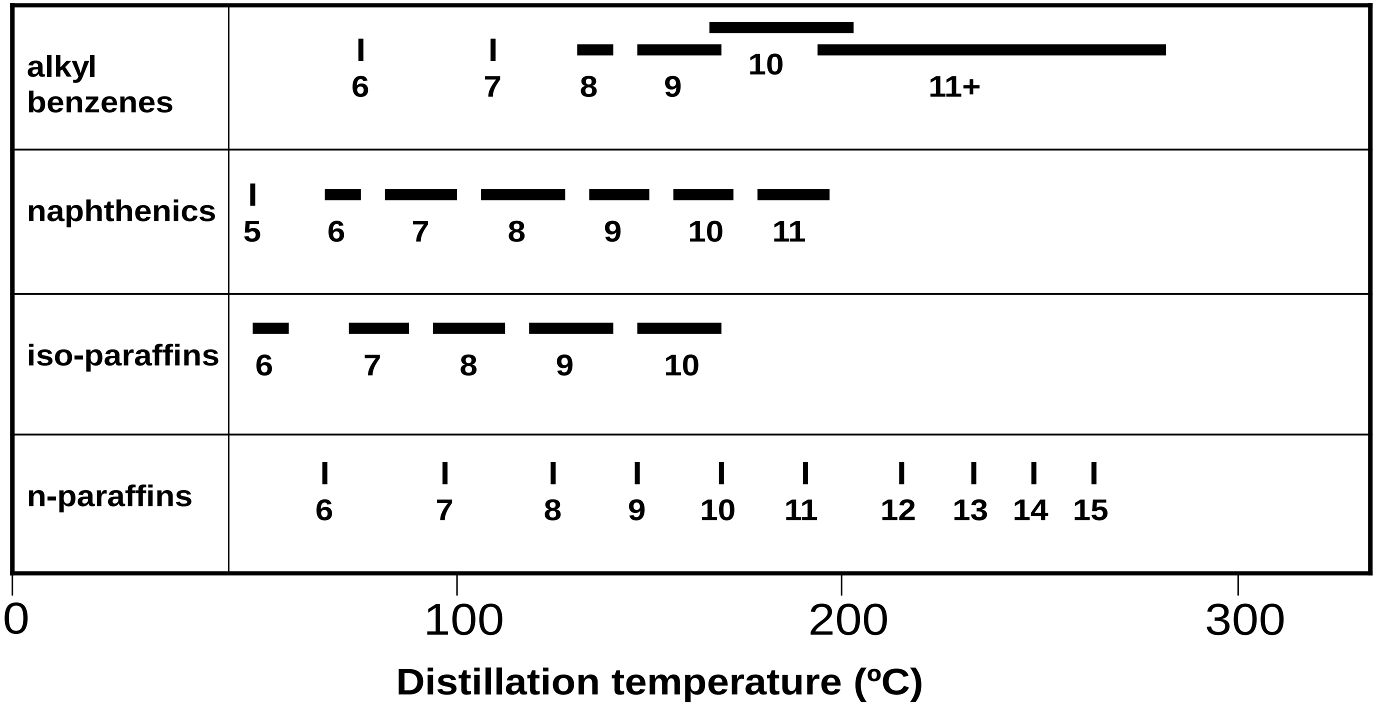


Table 1 - Substances Investigated in the 2013 Analytical Program

CONCAWE 2013 Analytical Program - Gas oils						
Sample No.	**Cross-Reference to 2015 Analytical Program**	**Category**	**Substance**	**CAS No.**	**EINECS No.**	**CAS Description**
CON 1	168	SRGO	Gas oils (petroleum), straight-run	64741-43-1	265-043-1	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
CON 2	169	SRGO	Distillates (petroleum), straight-run middle	64741-44-2	265-044-7	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C20 and boiling in the range of 205°C to 345°C (401°F to 653°F).
CON 3 (Substitute Sample)	170	SRGO	Distillates (petroleum), full-range straight-run middle	68814-87-9	272-341-5	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C25 and boiling in the range of approximately 150°C to 400°C (320°F to 752°F).
CON 3I (Lead Registrant Sample)		SRGO	Distillates (petroleum), full-range straight-run middle	68814-87-9	272-341-5	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C25 and boiling in the range of approximately 150°C to 400°C (320°F to 752°F).
CON 4 (Substitute Sample)	171	SRGO	Distillates (petroleum), heavy straight-run	68915-96-8	272-817-2	A complex combination of hydrocarbons produced by the atmospheric distillation of crude oil. It boils in the range of approximately 288°C to 471°C (550°F to 880°F).
CON 4I (Lead Registrant Sample)		SRGO	Distillates (petroleum), heavy straight-run	68915-96-8	272-817-2	A complex combination of hydrocarbons produced by the atmospheric distillation of crude oil. It boils in the range of approximately 288°C to 471°C (550°F to 880°F).
CON 5	172	SRGO	Gas oils (petroleum), straight-run, high-boiling	68915-97-9	272-818-8	A complex combination of hydrocarbons produced by the atmospheric distillation of crude oil. It boils in the range of approximately 282°C to 349°C (540°F to 660°F).
CON 6		OGO	Distillates (petroleum), sweetened middle	64741-86-2	265-088-7	A complex combination of hydrocarbons obtained by subjecting a petroleum distillate to a sweetening process to convert mercaptans or to remove acidic impurities. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).

CON 7	173	OGO	Distillates (petroleum), hydrotreated middle	64742-46-7	265-148-2	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
CON 8		OGO	Gas oils (petroleum), hydrodesulfurized	64742-79-6	265-182-8	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C13 through C25 and boiling in the range of approximately 230°C to 400°C (446°F to 752°F).
CON 9	174	OGO	Distillates (petroleum), hydrodesulfurized middle	64742-80-9	265-183-3	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
CON 10		OGO	Alkanes, C12-26-branched and linear	90622-53-0	292-454-3	No EC number description available in ESIS.
CON 11		OGO	Gas oils, paraffinic	93924-33-5	300-227-8	A distillate obtained from the redistillation of a complex combination of hydrocarbons obtained by the distillation of the effluents from a severe catalytic hydrotreatment of paraffins. It boils in the range of approximately 190°C to 330°C (374°F to 594°F).
CON 12	175	VHGO	Condensates (petroleum), vacuum tower	64741-49-7	265-049-4	A complex combination of hydrocarbons produced as the lowest boiling stream in the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
CON 13	176	VHGO	Gas oils (petroleum), light vacuum	64741-58-8	265-059-9	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C30 and boiling in the range of approximately 230°C to 450°C (446°F to 842°F).
CON 14	177	VHGO	Distillates (petroleum), light hydrocracked	64741-77-1	265-078-2	A complex combination of hydrocarbons from distillation of the products from a hydrocracking process. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C10 through C18, and boiling in the range of approximately 160°C to 320°C (320°F to 608°F).
CON 15	178	VHGO	Gas oils (petroleum), hydrodesulfurized light vacuum	64742-87-6	265-190-1	A complex combination of hydrocarbons obtained from a catalytic hydrodesulfurization process. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C30 and boiling in the range of approximately 230°C to 450°C (446°F to 842°F).
CON 16(i)	179	VHGO	Fuels, diesel	68334-30-5	269-822-7	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 163°C to 357°C (325°F to 675°F).

CON 16(ii)	180	VHGO	Fuels, diesel	68334-30-5	269-822-7	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 163°C to 357°C (325°F to 675°F).
CON 16(iii)		VHGO	Fuels, diesel	68334-30-5	269-822-7	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 163°C to 357°C (325°F to 675°F).
CON 17	181	VHGO	Fuel oil, no. 2	68476-30-2	270-671-4	A distillate oil having a minimum viscosity of 32.6 SUS at 37.7°C (100°F) to a maximum of 37.9 SUS at 37.7°C (100°F).
CON 18	182	VHGO	Fuel oil, no. 4	68476-31-3	270-673-5	A distillate oil having a minimum viscosity of 45 SUS at 37.7°C (100°F) to a maximum of 125 SUS at 37.7°C (100°F).
CON 19	183	VHGO	Fuels, diesel, no. 2	68476-34-6	270-676-1	A distillate oil having a minimum viscosity of 32.6 SUS at 37.7°C (100°F) to a maximum of 40.1 SUS at 37.7°C (100°F).
CON 20	184	VHGO	Gas oils (petroleum), hydrotreated light vacuum	92045-24-4	295-407-5	A complex combination of hydrocarbons that is obtained by treatment of light vacuum petroleum gas oils with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C30 and boiling in the range of approximately 230°C to 450°C (446°F to 842°F).

Notes

1. Sample CON 2 was initially classed as *"Distillates (petroleum), straight-run middle" (CAS No. 64741-44-2)* but following analysis was re-classified by Concawe as *"Distillates (petroleum), full-range straight-run middle" (CAS No. 68814-87-9).*
2. Sample CON 5 was initially classed as *"Gas oils (petroleum), straight-run, high-boiling" (CAS No. 68915-97-9)* but following analysis was re-classified by Concawe as *"Gas oils (petroleum), straight-run" (CAS No. 64741-43-1).*
3. Only a small volume (~500 mL) of Sample CON 10 was supplied, which was insufficient for any subsequent testing program, so this sample was not characterised.

4. Three samples of CON 16 were supplied, all classified as *"Fuels, diesel" (CAS No. 68334-30-5)*. The following information was supplied with the samples:

CON 16(i) -	Gasoil Heating DIN contains 32% straight-run kerosine and 68% of a desulfurised mixture (roughly 50% straight-run kerosine, 25% light straight-run gasoil and 25% light vacuum gasoil).
CON 16(ii) -	Gasoil Heating 50 ppm contains 80% straight-run kerosine and 20% straight-run light gasoil. This sample is also representative for diesel fuel (except for the sulphur level and it does not contain additives).
CON 16(iii) -	Diesel Oil. This is representative for marine gasoil (DMA) and contains 70% straight-run material and 30% LCO. This sample is representative for just a smaller portion of the products that are covered by CAS No. 68334-30-5. It should only be used in proportion.

CONCAWE 2013 Analytical Program - Bitumens

Sample No.	Cross-Reference to 2015 Analytical Program	Category	Substance	CAS No.	EINECS No.	CAS Description
CON 21		Bitumen	Asphalt	8052-42-4	232-490-9	A very complex combination of high molecular weight organic compounds containing a relatively high proportion of hydrocarbons having carbon numbers predominantly greater than C25 with high carbon-to-hydrogen ratios. It also contains small amounts of various metals such as nickel, iron, or vanadium. It is obtained as the non-volatile residue from distillation of crude oil or by separation as the raffinate from a residual oil in a deasphalting or decarbonization process.
CON 22		Bitumen	Residues (petroleum), vacuum	64741-56-6	265-057-8	A complex residuum from the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly greater than C34 and boiling above approximately 495°C (923°F).
CON 23		Bitumen	Residues (petroleum), thermal cracked vacuum	92062-05-0	295-518-9	A complex combination of hydrocarbons obtained from the vacuum distillation of the products from a thermal cracking process. It consists predominantly of hydrocarbons having carbon numbers predominantly greater than C34 and boiling above approximately 495°C (923°F).
CON 24		Bitumen	Residues (petroleum), distn. residue hydrogenation	100684-39-7	309-712-9	A complex combination of hydrocarbons obtained as a residue from the distillation of crude oil under vacuum. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range above C50 and boiling in the range above approximately 360°C (680°F).
CON 25		Bitumen	Residues (petroleum), vacuum distn. residue hydrogenation	100684-40-0	309-713-4	A complex combination of hydrocarbons obtained as a residue from the distillation of crude oil under vacuum. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range above C50 and boiling in the range above approximately 500°C (932°F).

CONCAWE 2013 Analytical Program - Residual Aromatic Extracts

Sample No.	Cross-Reference to 2015 Analytical Program	Category	Substance	CAS No.	EINECS No.	CAS Description
CON 26	185	RAE	Extracts (petroleum), residual oil solvent	64742-10-5	265-110-5	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly higher than C25.
CON 27	186	RAE	Extracts (petroleum), deasphalted vacuum residue solvent	91995-70-9	295-332-8	A complex combination of hydrocarbons obtained by solvent extraction of a vacuum deasphalted residue. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly greater than C30. This stream contains more than 5 wt. % of 4- to 6-membered condensed ring aromatic hydrocarbons.

Table 2 - Detailed Inventory of Substances Investigated in the 2015 Analytical Program (minus the excluded substances)

Table 3 - Summary of Substances Investigated in the 2015 Analytical Program (including the excluded substances)

Substance Category	Samples	CAS numbers	EC numbers
Bitumen	4	4	4
Cracked Gas Oils	8	8	8
Foots Oils	3	3	3
Heavy Fuel Oils	27	27	27
Highly Refined Base Oils	1	1	1
Kerosines	10	9	9
Low Boiling Point Naphthas	87	69	69
MK1 Diesel Fuel	1	see note	1
Other Gas Oils	4	3	3
Other Lubricant Base Oils	31	28	28
Oxidised Asphalt	2	1	1
Paraffin and Hydrocarbon Waxes	7	7	7
Petrolatums	4	4	4
Residual Aromatic Extracts	2	2	2
Slack Waxes	4	3	3
Straight-Run Gas Oils	6	4	4
Treated Distillate Aromatic Extracts	1	1	1
Unrefined / Acid Treated Oils	5	2	2
Untreated Distillate Aromatic Extracts	4	3	3
Vacuum Gas Oils, Hydrocracked Gas Oils and Distillate Fuels	10	9	9
Total	**221**	**188**	**189**

Note

Sample 049 (Kerosine) and Sample 059 (MK1 Diesel Fuel) have the same CAS number but different EC numbers.

Table 4 - Summary of Physical Distillation Results

Table 5 - Summary of SIMDIS-GC Results

Table 6 - Carbon Number Ranges in Petroleum Substance Descriptions

Specified range	Total number of carbon numbers (1)	Percentage distribution per carbon number (2)	10% of total number of carbon numbers	±10% of specified range	20% of total number of carbon numbers	±20% of specified range
C4-C5	2	50%	0.2	C4-C5	0.4	C4-C5
C5-C6	2	50%	0.2	C5-C6	0.4	C5-C6
C6-C7	2	50%	0.2	C6-C7	0.4	C6-C7
C7-C8	2	50%	0.2	C7-C8	0.4	C7-C8
C4-C6	3	33%	0.3	C4-C6	0.6	C3/5-C5/7
C5-C7	3	33%	0.3	C5-C7	0.6	C4/6-C6/8
C6-C8	3	33%	0.3	C6-C8	0.6	C5/7-C7/9
C8-C10	3	33%	0.3	C8-C10	0.6	C7/9-C9/11
C3-C6	4	25%	0.4	C3-C6	0.8	C2/4-C5/7
C5-C8	4	25%	0.4	C5-C8	0.8	C4/6-C7/9
C6-C9	4	25%	0.4	C6-C9	0.8	C5/7-C8/10
C7-C10	4	25%	0.4	C7-C10	0.8	C6/8-C9/11
C9-C12	4	25%	0.4	C9-C12	0.8	C8/10-C11/13
C4-C8	5	20%	0.5	C3/C5-C7/C9	1.0	C3/5-C7/9
C5-C9	5	20%	0.5	C4/6-C8/10	1.0	C4/6-C8/10
C6-C10	5	20%	0.5	C5/7-C9/11	1.0	C5/7-C9/11
C2-C7	6	17%	0.6	C1/3-C6/8	1.2	C1/3-C6/8
C4-C9	6	17%	0.6	C3/5-C8/10	1.2	C3/5-C8/10
C5-C10	6	17%	0.6	C4/6-C9/11	1.2	C4/6-C9/11
C6-C11	6	17%	0.6	C5/7-C10/12	1.2	C5/7-C10/12

Specified range	Total number of carbon numbers (1)	Percentage distribution per carbon number (2)	10% of total number of carbon numbers	±10% of specified range	20% of total number of carbon numbers	±20% of specified range
C7-C12	6	17%	0.6	C6/8-C11/13	1.2	C6/8-C11/13
C11-16	6	17%	0.6	C10/12-C15/17	1.2	C10/12-C15/17
C4-C10	7	14%	0.7	C3/5-C9/11	1.4	C3/5-C9/11
C5-C11	7	14%	0.7	C4/6-C10/12	1.4	C4/6-C10/12
C6-C12	7	14%	0.7	C5/7-C11/13	1.4	C5/7-C11/13
C4-C11	8	13%	0.8	C3/5-C10/12	1.6	C2/6-C9/13
C5-C12	8	13%	0.8	C4/6-C11/13	1.6	C3/7-C10/14
C6-C13	8	13%	0.8	C5/7-C12/14	1.6	C4/8-C11/15
C9-C16	8	13%	0.8	C8/10-C15/17	1.6	C7/11-C14/18
C3-C11	9	11%	0.9	C2/4-C10/12	1.8	C1/5-C9/13
C4-C12	9	11%	0.9	C3/5-C11/13	1.8	C2/6-C10/14
C10-C18	9	11%	0.9	C9/11-C17/19	1.8	C8/12-C16/20
C21-C29	9	11%	0.9	C20/22-C28/30	1.8	C19/23-C27/31
C11-C20	10	10%	1.0	C10/12-C19/21	2.0	C9/13-C18/22
C12-C21	10	10%	1.0	C11/13-C20/22	2.0	C10/14-C19/23
C4-C15	12	8%	1.2	C3/5-C14/16	2.4	C2/6-C13/17
C9-C20	12	8%	1.2	C8/10-C19-21	2.4	C7/11-C18/22
C10-C22	13	8%	1.3	C9/11-C21/23	2.6	C7/13-C19/25
C13-C25	13	8%	1.3	C12/14-C24/26	2.6	C10/16-C22/28
C17-C30	14	7%	1.4	C16/18-C29/31	2.8	C14/20-C27/33
C11-C25	15	7%	1.5	C9/13-C23/27	3.0	C8/14-C22/28

Specified range	Total number of carbon numbers (1)	Percentage distribution per carbon number (2)		10% of total number of carbon numbers	±10% of specified range		20% of total number of carbon numbers	±20% of specified range
C9-C24	16	6%		1.6	C7/11-C22/26		3.2	C6/12-C21/27
C10-C25	16	6%		1.6	C8/12-C23/27		3.2	C7/13-C22/28
C15-C30	16	6%		1.6	C13/17-C28/32		3.2	C12/18-C27/33
C9-C25	17	6%		1.7	C7/11-C23/27		3.4	C6/12-C22/28
C13-C30	18	6%		1.8	C11/15-C28/32		3.6	C9/17-C26/34
C2-C20	19	5%		1.9	C0/4-C18/22		3.8	C0/6-C16/24
C11-C30	20	5%		2.0	C9/13-C28/32		4.0	C7/15-C26/34
C15-C35	21	5%		2.1	C13/17-C33/37		4.2	C11/19-C31/39
C15-C36	22	5%		2.2	C13/17-C34/38		4.4	C11/19-C32/40
C18-C40	23	4%		2.3	C16/20-C38/42		4.6	C13/23-C35/45
C11-C35	25	4%		2.5	C8/14-C32/38		5.0	C6/16-C30/40
C15-C39	25	4%		2.5	C12/18-C36/42		5.0	C10/20-C34/44
C25-C50	26	4%		2.6	C22/28-C47/53		5.2	C20/30-C45/55
C24-C50	27	4%		2.7	C21/27-C47/53		5.4	C19/29-C45/55
C7-C35	29	3%		2.9	C4/10-C32/38		5.8	C1/13-C29/41
C14-C42	29	3%		2.9	C11/17-C39/45		5.8	C8/20-C36/48
C15-C45	31	3%		3.1	C12/18-C42/48		6.2	C9/21-C39/51
C20-C50	31	3%		3.1	C17/23-C47/53		6.2	C14/26-C44/56
C15-C50	36	3%		3.6	C11/19-C46/54		7.2	C8/22-C43/57
C13-C50	38	3%		3.8	C9/17-C46/54		7.6	C5/21-C42/58
C11-C50	40	3%		4.0	C7/15-C46/54		8.0	C3/19-C42/58

Specified range	Total number of carbon numbers (1)	Percentage distribution per carbon number (2)	10% of total number of carbon numbers	±10% of specified range	20% of total number of carbon numbers	±20% of specified range
C20-C60	41	2%	4.1	C16/24-C56/64	8.2	C12/28-C52/68
C15-C60	46	2%	4.6	C10/20-C55/65	9.2	C6/24-C51/69
>C3	98	1%	9.8	>C3/13	19.6	>C3/23
>C11	90	1%	9.0	>C11/20	18.0	>C11/29
>C13	88	1%	8.8	>C13/22	17.6	>C13/31
>C20	81	1%	8.1	>C20/28	16.2	>C20/36
>C24	77	1%	7.7	>C24/32	15.4	>C24/39
>C25	76	1%	7.6	>C25/33	15.2	>C25/40
>C30	71	1%	7.1	>C30/37	14.2	>C30/44
>C34	67	1%	6.7	>C34/41	13.4	>C34/47
>C35	66	2%	6.6	>C35/42	13.2	>C35/48
C5	1	100%	0.1	C5	0.2	C5
C6	1	100%	0.1	C6	0.2	C6
C7	1	100%	0.1	C7	0.2	C7
C8	1	100%	0.1	C8	0.2	C8

Notes

1. If only the lower carbon number is quoted in the substance description, C100 is assumed to be the upper carbon number.
2. Percentage distributions per carbon number have been rounded to nearest integer.

Table 7 - Summary of Decision Tree Results (including the excluded substances)

Decision tree criterion	Number of samples meeting criterion
Accept ②	5
Accept ⑥	42
Accept ⑧	26
Accept ⑨	32
Review ①	7
Review ⑤	89
Review ⑦	13
Reject ③	6
Reject ④	1

Table 8 - Summary of GCxGC Results

Table 9 - Summary of DHA-GC Results

Table 10 - Summary of PIONA-GC Results

Table 11 - Summary of PAH Results

Table 12 - Summary of PAC-2 Results

Table 13 - Summary of Elemental Analysis Results

Table 14 - Carbon : Hydrogen Ratios

Table 15 - Summary of FIMS Results

- Z5499Data_Sample_085A_CM5283668_Arom
- Z5498Data_Sample_074_CM5283665_Arom
- Z5497Data_Sample_085A_CM5283668_Sats
- Z5496Data_Sample_074_CM5283665_Sats
- Z5548Data_Sample_081_CM5283667_Arom
- Z5544Data_Sample_081_CM5283667_Sats
- Z5514Data_Sample_072_CM5283663_Arom
- Z5512Data_Sample_085B_CM5283669_Arom
- Z5511Data_Sample_075_CM5283666_Arom
- Z5510Data_Sample_066_CM5283662_Arom
- Z5509Data_Sample_073_CM5283644_Arom
- Z5507Data_Sample_085B_CM5283669_Sats
- Z5506Data_Sample_075_CM5283666_Sats
- Z5505Data_Sample_073_CM5283664_Sats
- Z5503Data_Sample_072_CM5283663_Sats
- Z5502Data_Sample_066_CM5283662_Sats
- Z5526Data_Sample_092_CM5283672_Sats
- Z5532Data_Sample_092_CM5283672_Arom
- Z5580Data_Sample_150_CM5283689_Arom
- Z5581Data_Sample_151_CM5283690_Arom
- Z5525Data_Sample_085D_CM5283671_Sats
- Z5513Data_Sample_085C_CM5283670_Arom
- Z5508Data_Sample_085C_CM5283670_Sats
- Z5561Data_Sample_119_CM5283680_Sats
- Z5560Data_Sample_118_CM5283679_Sats
- Z5551Data_Sample_117_CM5283678_Arom
- Z5550Data_Sample_115_CM5283677_Arom
- Z5547Data_Sample_117_CM5283678_Sats
- Z5545Data_Sample_115_CM5283677_Sats
- Z5535Data_Sample_085D_CM5283671_Arom
- Z5579Data_Sample_148_CM5283687_Arom
- Z5578Data_Sample_147_CM5283686_Arom
- Z5574Data_Sample_154_CM5283692_Sats
- Z5573Data_Sample_153_CM5283691_Sats
- Z5572Data_Sample_151_CM5283690_Sats
- Z5566Data_Sample_150_CM5283689_Sats
- Z5565Data_Sample_148_CM5283687_Sats
- Z5563Data_Sample_147_CM5283686_Sats
- Z5490Data_Sample_145_CM5283685_Sats
- Z5599Data_Sample_149_CM5283688_Arom
- Z5598Data_Sample_140_CM5283684_Arom

- Z5597Data_Sample_139_CM5283683_Arom
- Z5595Data_Sample_138_CM5283682_Arom
- Z5594Data_Sample_137_CM5283681_Arom
- Z5593Data_Sample_149_CM5283688_Sats
- Z5592Data_Sample_140_CM5283684_Sats
- Z5590Data_Sample_139_CM5283683_Sats
- Z5589Data_Sample_138_CM5283682_Sats
- Z5588Data_Sample_137_CM5283681_Sats
- Z5541Data_Sample_OLBO1_CM5283660_Arom
- Z5539Data_Sample_OLBO1_CM5283660_Sats
- Z5515Data_Sample_OLBO2_CM5283661_Arom
- Z5501Data_Sample_OLBO2_CM5283661_Sats
- Z5531Data_Sample_OLBO3_CM5283673_Arom
- Z5527Data_Sample_OLBO3_CM5283673_Sats
- Z5528Data_Sample_OLBO4_CM5283674_Sats
- Z5534Data_Sample_OLBO4_CM5283674_Arom
- Z5538Data_Sample_OLBO5_CM5283675_Sats
- Z5536Data_Sample_OLBO5_CM5283675_Arom
- Z5549Data_Sample_OLBO6_CM5283676_Arom
- Z5543Data_Sample_OLBO6_CM5283676_Sats

Table 16 - 3D Images of FIMS Results

Table 17 - Summary of PCA Results

Table 18 - Summary of HPLC Results

Table 19 - Comparison of HPLC and GCxGC Results from 2015 Analytical Program

Table 20 - Summary of TLC-FID Results

Table 21 - Summary of LCC Results

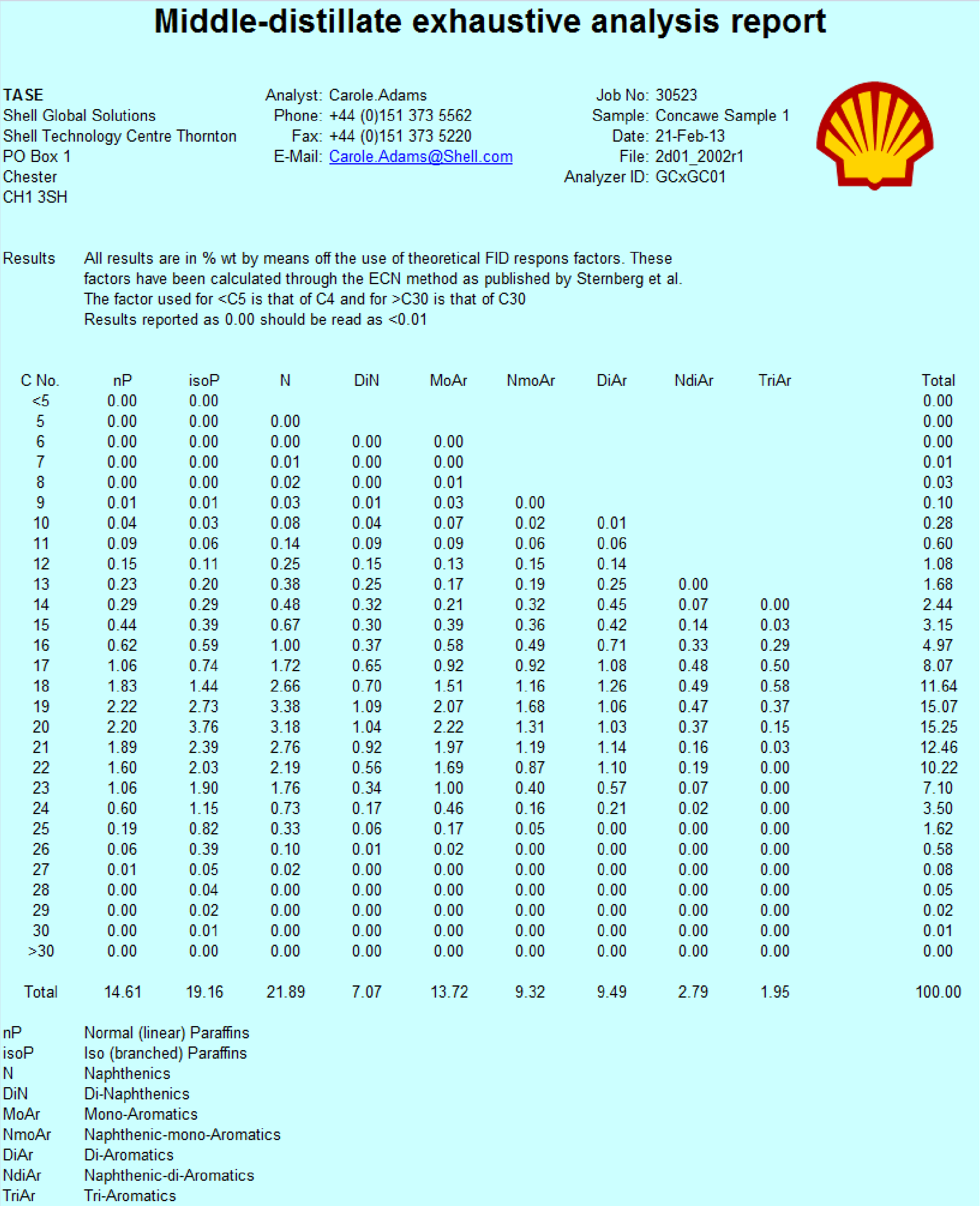
Table 22 - Comparison of LCC and TLC-FID Results from 2015 Analytical Program

Table 23 - Summary of Viscosity Results

Table 24 - Summary of Samples Examined by GCxGC

APPENDIX 1 - GCXGC RESULTS FOR SAMPLES ANALYSED IN THE 2013 ANALYTICAL PROGRAM

CON 1 (SRGO)



Middle-distillate exhaustive analysis report

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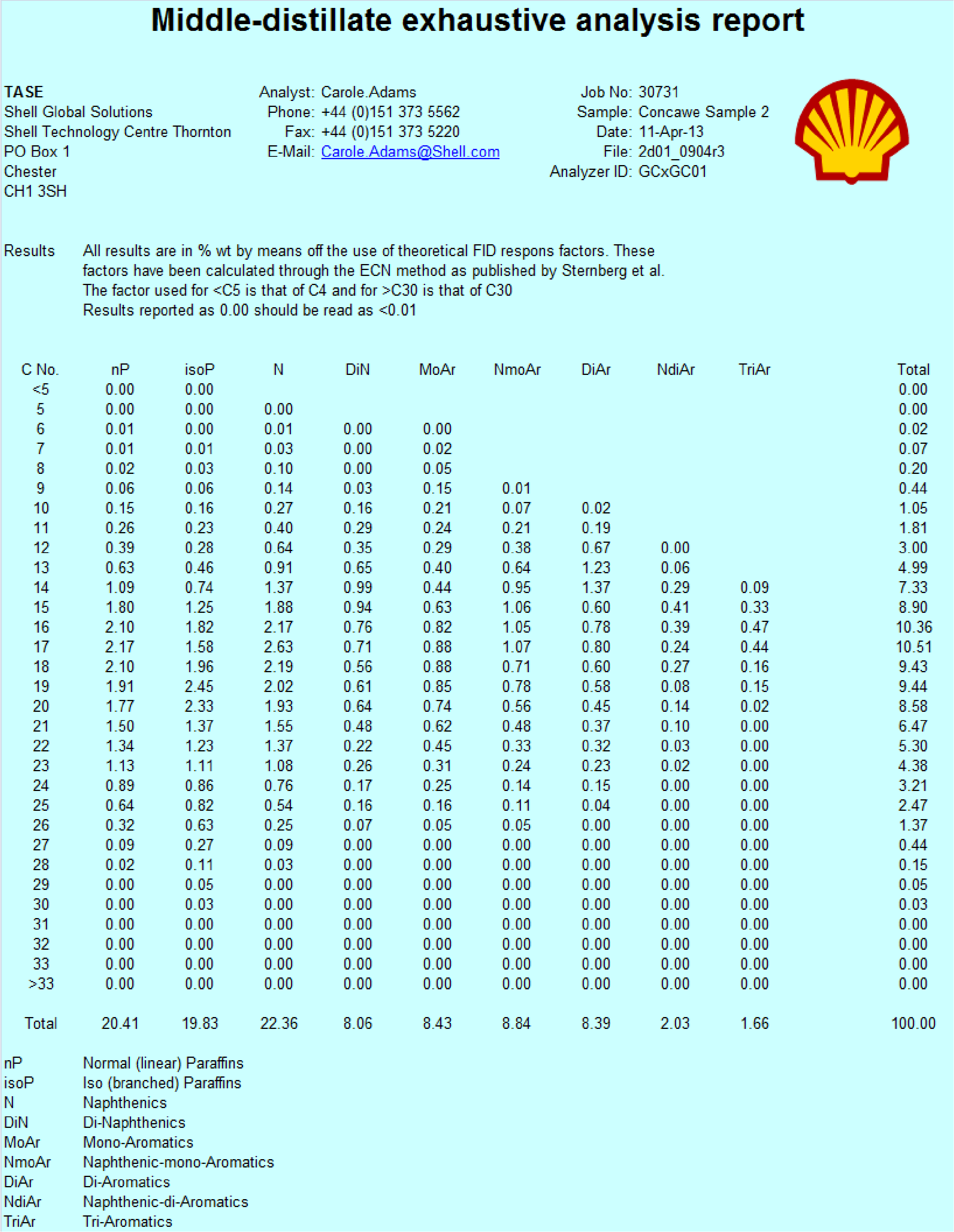
Job No: 30523
Sample: Concawe Sample 1
Date: 21-Feb-13
File: 2d01_2002r1
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.01	0.00	0.00					0.01
8	0.00	0.00	0.02	0.00	0.01					0.03
9	0.01	0.01	0.03	0.01	0.03	0.00				0.10
10	0.04	0.03	0.08	0.04	0.07	0.02	0.01			0.28
11	0.09	0.06	0.14	0.09	0.09	0.06	0.06			0.60
12	0.15	0.11	0.25	0.15	0.13	0.15	0.14			1.08
13	0.23	0.20	0.38	0.25	0.17	0.19	0.25	0.00		1.68
14	0.29	0.29	0.48	0.32	0.21	0.32	0.45	0.07	0.00	2.44
15	0.44	0.39	0.67	0.30	0.39	0.36	0.42	0.14	0.03	3.15
16	0.62	0.59	1.00	0.37	0.58	0.49	0.71	0.33	0.29	4.97
17	1.06	0.74	1.72	0.65	0.92	0.92	1.08	0.48	0.50	8.07
18	1.83	1.44	2.66	0.70	1.51	1.16	1.26	0.49	0.58	11.64
19	2.22	2.73	3.38	1.09	2.07	1.68	1.06	0.47	0.37	15.07
20	2.20	3.76	3.18	1.04	2.22	1.31	1.03	0.37	0.15	15.25
21	1.89	2.39	2.76	0.92	1.97	1.19	1.14	0.16	0.03	12.46
22	1.60	2.03	2.19	0.56	1.69	0.87	1.10	0.19	0.00	10.22
23	1.06	1.90	1.76	0.34	1.00	0.40	0.57	0.07	0.00	7.10
24	0.60	1.15	0.73	0.17	0.46	0.16	0.21	0.02	0.00	3.50
25	0.19	0.82	0.33	0.06	0.17	0.05	0.00	0.00	0.00	1.62
26	0.06	0.39	0.10	0.01	0.02	0.00	0.00	0.00	0.00	0.58
27	0.01	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.08
28	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
29	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
30	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
>30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	14.61	19.16	21.89	7.07	13.72	9.32	9.49	2.79	1.95	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 2 (SRGO)



Middle-distillate exhaustive analysis report

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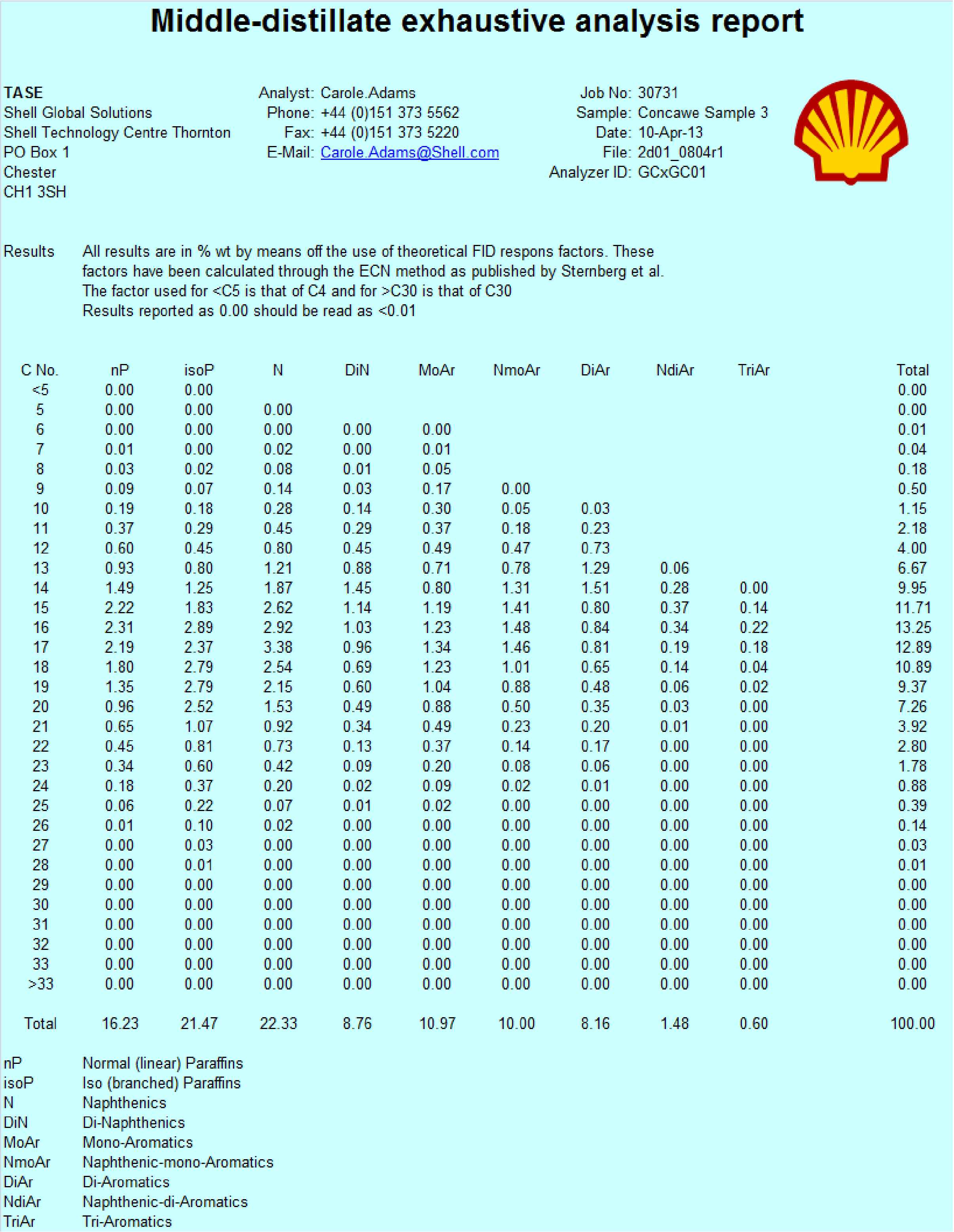
Job No: 30731
Sample: Concawe Sample 2
Date: 11-Apr-13
File: 2d01_0904r3
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.01	0.00	0.01	0.00	0.00					0.02
7	0.01	0.01	0.03	0.00	0.02					0.07
8	0.02	0.03	0.10	0.00	0.05					0.20
9	0.06	0.06	0.14	0.03	0.15	0.01				0.44
10	0.15	0.16	0.27	0.16	0.21	0.07	0.02			1.05
11	0.26	0.23	0.40	0.29	0.24	0.21	0.19			1.81
12	0.39	0.28	0.64	0.35	0.29	0.38	0.67	0.00		3.00
13	0.63	0.46	0.91	0.65	0.40	0.64	1.23	0.06		4.99
14	1.09	0.74	1.37	0.99	0.44	0.95	1.37	0.29	0.09	7.33
15	1.80	1.25	1.88	0.94	0.63	1.06	0.60	0.41	0.33	8.90
16	2.10	1.82	2.17	0.76	0.82	1.05	0.78	0.39	0.47	10.36
17	2.17	1.58	2.63	0.71	0.88	1.07	0.80	0.24	0.44	10.51
18	2.10	1.96	2.19	0.56	0.88	0.71	0.60	0.27	0.16	9.43
19	1.91	2.45	2.02	0.61	0.85	0.78	0.58	0.08	0.15	9.44
20	1.77	2.33	1.93	0.64	0.74	0.56	0.45	0.14	0.02	8.58
21	1.50	1.37	1.55	0.48	0.62	0.48	0.37	0.10	0.00	6.47
22	1.34	1.23	1.37	0.22	0.45	0.33	0.32	0.03	0.00	5.30
23	1.13	1.11	1.08	0.26	0.31	0.24	0.23	0.02	0.00	4.38
24	0.89	0.86	0.76	0.17	0.25	0.14	0.15	0.00	0.00	3.21
25	0.64	0.82	0.54	0.16	0.16	0.11	0.04	0.00	0.00	2.47
26	0.32	0.63	0.25	0.07	0.05	0.05	0.00	0.00	0.00	1.37
27	0.09	0.27	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.44
28	0.02	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.15
29	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
30	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.41	19.83	22.36	8.06	8.43	8.84	8.39	2.03	1.66	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 3 (SRGO)



Middle-distillate exhaustive analysis report

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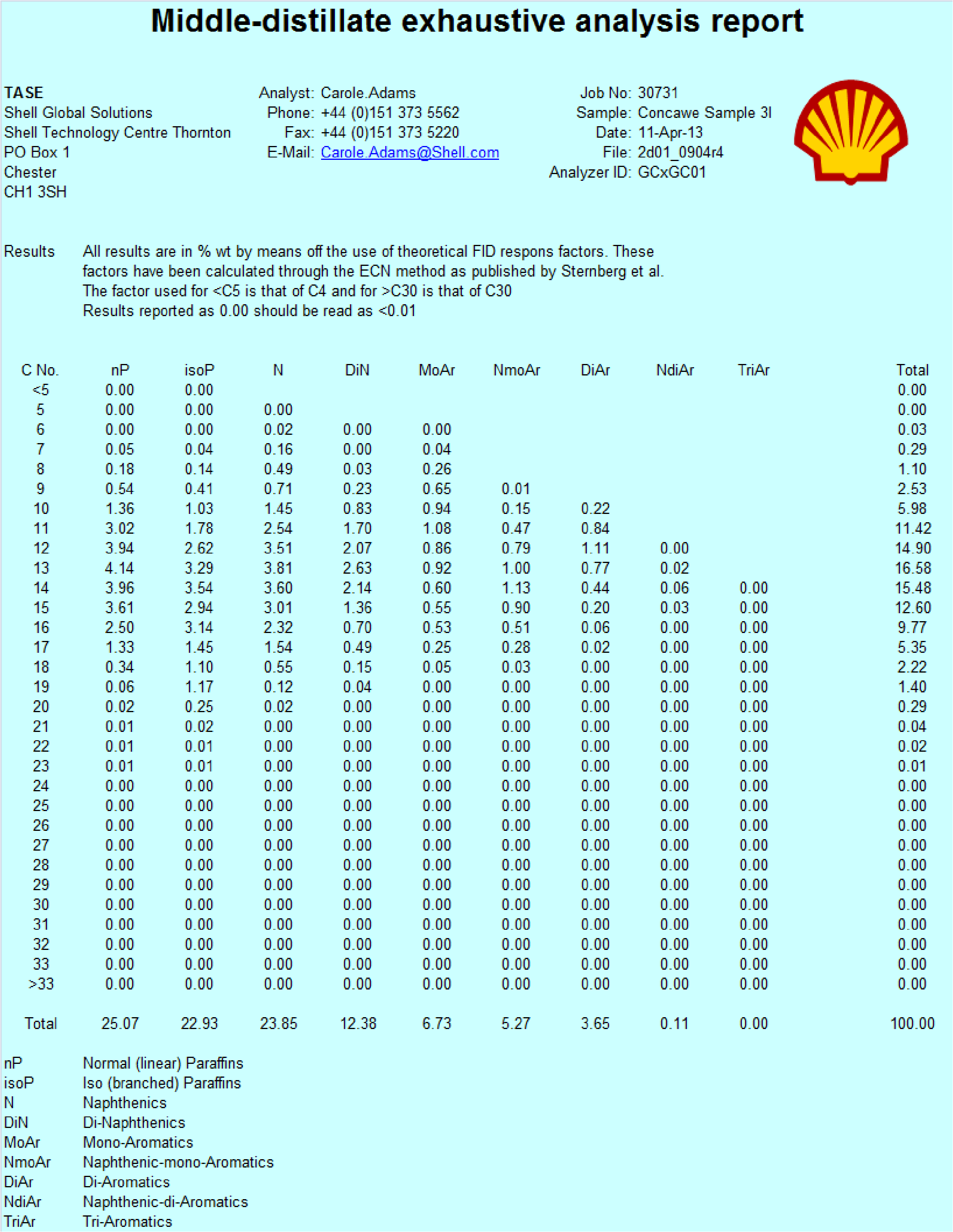
Job No: 30731
Sample: Concawe Sample 3
Date: 10-Apr-13
File: 2d01_0804r1
Analyzer ID: GCxGC01

Results	All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30 Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.01
7	0.01	0.00	0.02	0.00	0.01					0.04
8	0.03	0.02	0.08	0.01	0.05					0.18
9	0.09	0.07	0.14	0.03	0.17	0.00				0.50
10	0.19	0.18	0.28	0.14	0.30	0.05	0.03			1.15
11	0.37	0.29	0.45	0.29	0.37	0.18	0.23			2.18
12	0.60	0.45	0.80	0.45	0.49	0.47	0.73			4.00
13	0.93	0.80	1.21	0.88	0.71	0.78	1.29	0.06		6.67
14	1.49	1.25	1.87	1.45	0.80	1.31	1.51	0.28	0.00	9.95
15	2.22	1.83	2.62	1.14	1.19	1.41	0.80	0.37	0.14	11.71
16	2.31	2.89	2.92	1.03	1.23	1.48	0.84	0.34	0.22	13.25
17	2.19	2.37	3.38	0.96	1.34	1.46	0.81	0.19	0.18	12.89
18	1.80	2.79	2.54	0.69	1.23	1.01	0.65	0.14	0.04	10.89
19	1.35	2.79	2.15	0.60	1.04	0.88	0.48	0.06	0.02	9.37
20	0.96	2.52	1.53	0.49	0.88	0.50	0.35	0.03	0.00	7.26
21	0.65	1.07	0.92	0.34	0.49	0.23	0.20	0.01	0.00	3.92
22	0.45	0.81	0.73	0.13	0.37	0.14	0.17	0.00	0.00	2.80
23	0.34	0.60	0.42	0.09	0.20	0.08	0.06	0.00	0.00	1.78
24	0.18	0.37	0.20	0.02	0.09	0.02	0.01	0.00	0.00	0.88
25	0.06	0.22	0.07	0.01	0.02	0.00	0.00	0.00	0.00	0.39
26	0.01	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.14
27	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
28	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	16.23	21.47	22.33	8.76	10.97	10.00	8.16	1.48	0.60	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 3I (SRGO)



Middle-distillate exhaustive analysis report

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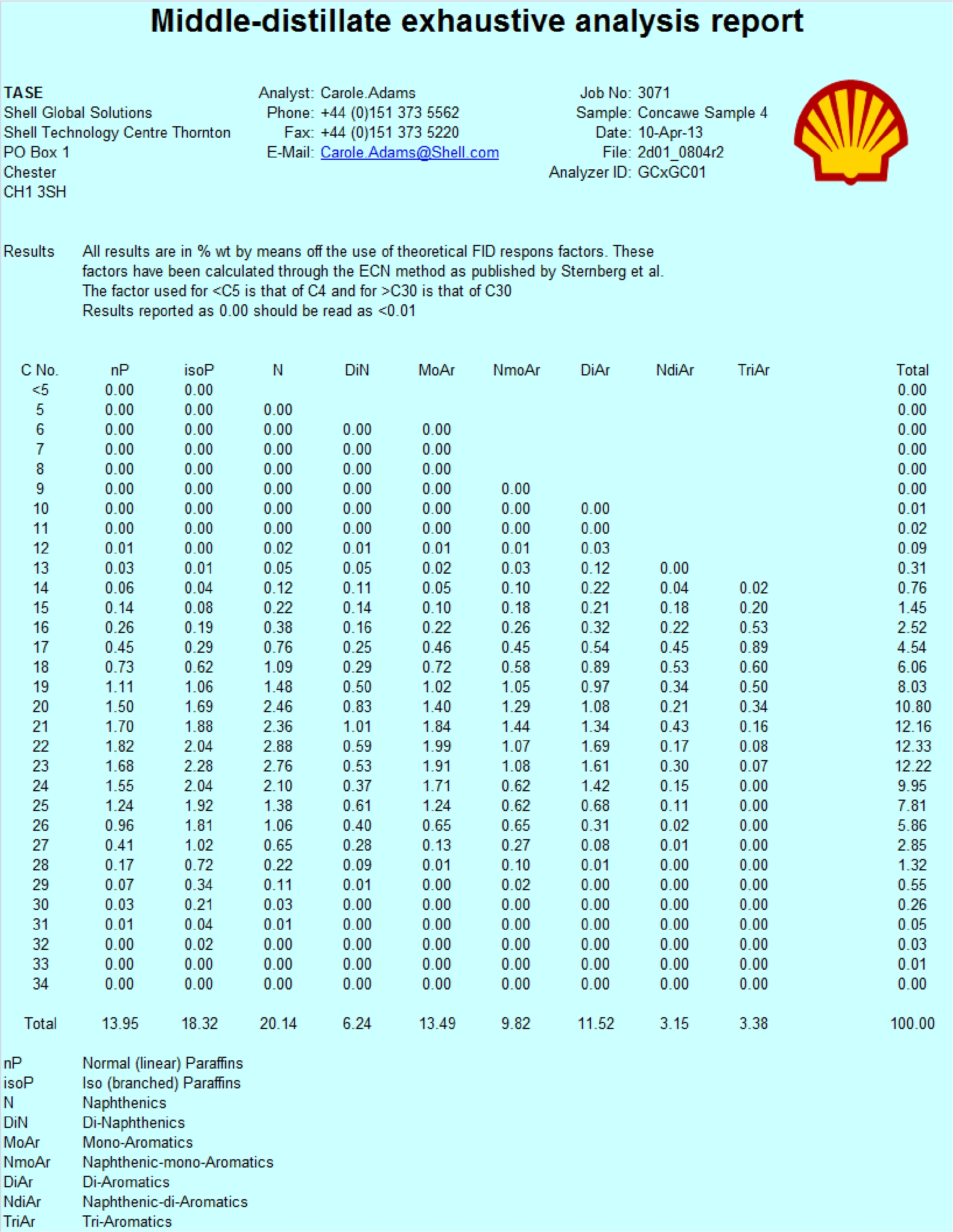
Job No: 30731
Sample: Concawe Sample 3I
Date: 11-Apr-13
File: 2d01_0904r4
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30 Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.02	0.00	0.00					0.03
7	0.05	0.04	0.16	0.00	0.04					0.29
8	0.18	0.14	0.49	0.03	0.26					1.10
9	0.54	0.41	0.71	0.23	0.65	0.01				2.53
10	1.36	1.03	1.45	0.83	0.94	0.15	0.22			5.98
11	3.02	1.78	2.54	1.70	1.08	0.47	0.84			11.42
12	3.94	2.62	3.51	2.07	0.86	0.79	1.11	0.00		14.90
13	4.14	3.29	3.81	2.63	0.92	1.00	0.77	0.02		16.58
14	3.96	3.54	3.60	2.14	0.60	1.13	0.44	0.06	0.00	15.48
15	3.61	2.94	3.01	1.36	0.55	0.90	0.20	0.03	0.00	12.60
16	2.50	3.14	2.32	0.70	0.53	0.51	0.06	0.00	0.00	9.77
17	1.33	1.45	1.54	0.49	0.25	0.28	0.02	0.00	0.00	5.35
18	0.34	1.10	0.55	0.15	0.05	0.03	0.00	0.00	0.00	2.22
19	0.06	1.17	0.12	0.04	0.00	0.00	0.00	0.00	0.00	1.40
20	0.02	0.25	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.29
21	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
22	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
23	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	25.07	22.93	23.85	12.38	6.73	5.27	3.65	0.11	0.00	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 4 (SRGO)



Middle-distillate exhaustive analysis report

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Job No: 3071
Sample: Concawe Sample 4
Date: 10-Apr-13
File: 2d01_0804r2
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.00
9	0.00	0.00	0.00	0.00	0.00	0.00				0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.02
12	0.01	0.00	0.02	0.01	0.01	0.01	0.03			0.09
13	0.03	0.01	0.05	0.05	0.02	0.03	0.12	0.00		0.31
14	0.06	0.04	0.12	0.11	0.05	0.10	0.22	0.04	0.02	0.76
15	0.14	0.08	0.22	0.14	0.10	0.18	0.21	0.18	0.20	1.45
16	0.26	0.19	0.38	0.16	0.22	0.26	0.32	0.22	0.53	2.52
17	0.45	0.29	0.76	0.25	0.46	0.45	0.54	0.45	0.89	4.54
18	0.73	0.62	1.09	0.29	0.72	0.58	0.89	0.53	0.60	6.06
19	1.11	1.06	1.48	0.50	1.02	1.05	0.97	0.34	0.50	8.03
20	1.50	1.69	2.46	0.83	1.40	1.29	1.08	0.21	0.34	10.80
21	1.70	1.88	2.36	1.01	1.84	1.44	1.34	0.43	0.16	12.16
22	1.82	2.04	2.88	0.59	1.99	1.07	1.69	0.17	0.08	12.33
23	1.68	2.28	2.76	0.53	1.91	1.08	1.61	0.30	0.07	12.22
24	1.55	2.04	2.10	0.37	1.71	0.62	1.42	0.15	0.00	9.95
25	1.24	1.92	1.38	0.61	1.24	0.62	0.68	0.11	0.00	7.81
26	0.96	1.81	1.06	0.40	0.65	0.65	0.31	0.02	0.00	5.86
27	0.41	1.02	0.65	0.28	0.13	0.27	0.08	0.01	0.00	2.85
28	0.17	0.72	0.22	0.09	0.01	0.10	0.01	0.00	0.00	1.32
29	0.07	0.34	0.11	0.01	0.00	0.02	0.00	0.00	0.00	0.55
30	0.03	0.21	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.26
31	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05
32	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	13.95	18.32	20.14	6.24	13.49	9.82	11.52	3.15	3.38	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 4I (SRGO)

Middle-distillate exhaustive analysis report

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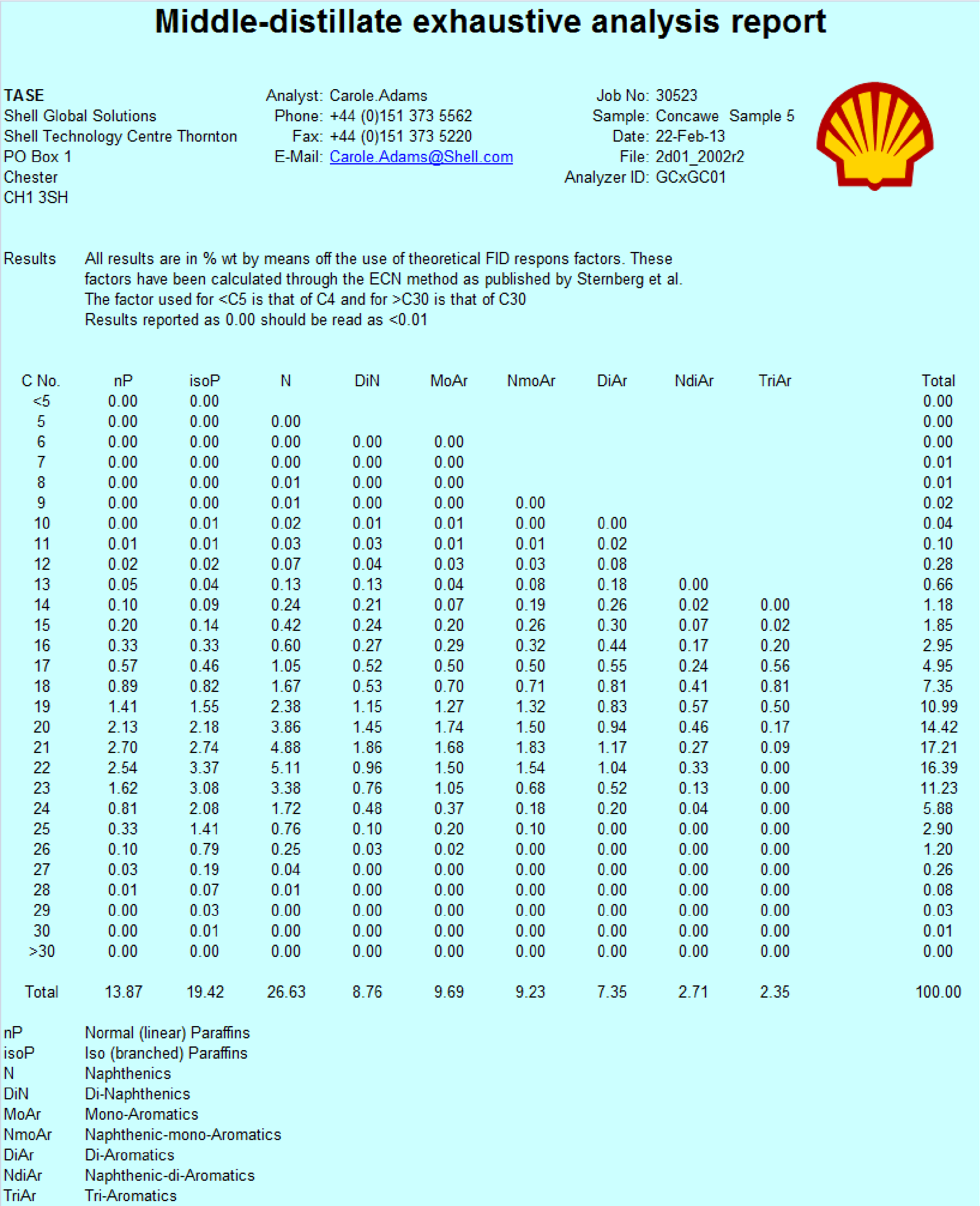
Job No: 30731
Sample: Concawe Sample 4I
Date: 13-May-13
File: 2d01_0805r1
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.01	0.00	0.01	0.00	0.00					0.02
8	0.01	0.01	0.01	0.00	0.00					0.03
9	0.02	0.01	0.01	0.00	0.00	0.00				0.05
10	0.04	0.02	0.01	0.00	0.00	0.00	0.00			0.08
11	0.09	0.03	0.02	0.01	0.00	0.00	0.00			0.16
12	0.17	0.04	0.05	0.01	0.00	0.00	0.01			0.28
13	0.28	0.07	0.08	0.05	0.01	0.01	0.02	0.00		0.50
14	0.43	0.11	0.13	0.10	0.02	0.02	0.01	0.00	0.00	0.82
15	0.71	0.13	0.20	0.08	0.02	0.02	0.01	0.02	0.06	1.24
16	1.05	0.27	0.27	0.05	0.05	0.04	0.01	0.03	0.18	1.93
17	1.56	0.33	0.53	0.10	0.06	0.07	0.02	0.06	0.17	2.91
18	2.42	0.55	0.79	0.13	0.14	0.13	0.06	0.08	0.04	4.35
19	4.74	1.06	1.61	0.29	0.18	0.35	0.13	0.04	0.01	8.41
20	9.64	2.06	2.89	0.57	0.46	0.60	0.18	0.04	0.00	16.45
21	12.27	3.36	3.22	0.51	0.60	0.61	0.19	0.02	0.00	20.77
22	8.74	3.28	2.73	0.33	0.48	0.29	0.12	0.00	0.00	15.96
23	5.91	2.84	1.75	0.13	0.33	0.18	0.06	0.00	0.00	11.20
24	3.50	1.86	0.98	0.06	0.14	0.07	0.01	0.00	0.00	6.62
25	2.05	1.11	0.55	0.05	0.06	0.05	0.00	0.00	0.00	3.87
26	1.07	0.82	0.30	0.03	0.04	0.03	0.00	0.00	0.00	2.29
27	0.57	0.32	0.16	0.03	0.00	0.02	0.00	0.00	0.00	1.10
28	0.25	0.20	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.51
29	0.13	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.23
30	0.05	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.11
31	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
32	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
33	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	55.74	18.62	16.41	2.55	2.59	2.49	0.82	0.29	0.46	99.96

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 5 (SRGO)



Middle-distillate exhaustive analysis report

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Job No: 30523
Sample: Concawe Sample 5
Date: 22-Feb-13
File: 2d01_2002r2
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.01
8	0.00	0.00	0.01	0.00	0.00					0.01
9	0.00	0.00	0.01	0.00	0.00	0.00				0.02
10	0.00	0.01	0.02	0.01	0.01	0.00	0.00			0.04
11	0.01	0.01	0.03	0.03	0.01	0.01	0.02			0.10
12	0.02	0.02	0.07	0.04	0.03	0.03	0.08			0.28
13	0.05	0.04	0.13	0.13	0.04	0.08	0.18	0.00		0.66
14	0.10	0.09	0.24	0.21	0.07	0.19	0.26	0.02	0.00	1.18
15	0.20	0.14	0.42	0.24	0.20	0.26	0.30	0.07	0.02	1.85
16	0.33	0.33	0.60	0.27	0.29	0.32	0.44	0.17	0.20	2.95
17	0.57	0.46	1.05	0.52	0.50	0.50	0.55	0.24	0.56	4.95
18	0.89	0.82	1.67	0.53	0.70	0.71	0.81	0.41	0.81	7.35
19	1.41	1.55	2.38	1.15	1.27	1.32	0.83	0.57	0.50	10.99
20	2.13	2.18	3.86	1.45	1.74	1.50	0.94	0.46	0.17	14.42
21	2.70	2.74	4.88	1.86	1.68	1.83	1.17	0.27	0.09	17.21
22	2.54	3.37	5.11	0.96	1.50	1.54	1.04	0.33	0.00	16.39
23	1.62	3.08	3.38	0.76	1.05	0.68	0.52	0.13	0.00	11.23
24	0.81	2.08	1.72	0.48	0.37	0.18	0.20	0.04	0.00	5.88
25	0.33	1.41	0.76	0.10	0.20	0.10	0.00	0.00	0.00	2.90
26	0.10	0.79	0.25	0.03	0.02	0.00	0.00	0.00	0.00	1.20
27	0.03	0.19	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.26
28	0.01	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.08
29	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
30	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
>30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	13.87	19.42	26.63	8.76	9.69	9.23	7.35	2.71	2.35	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 6 (OGO)

Middle-distillate exhaustive analysis report

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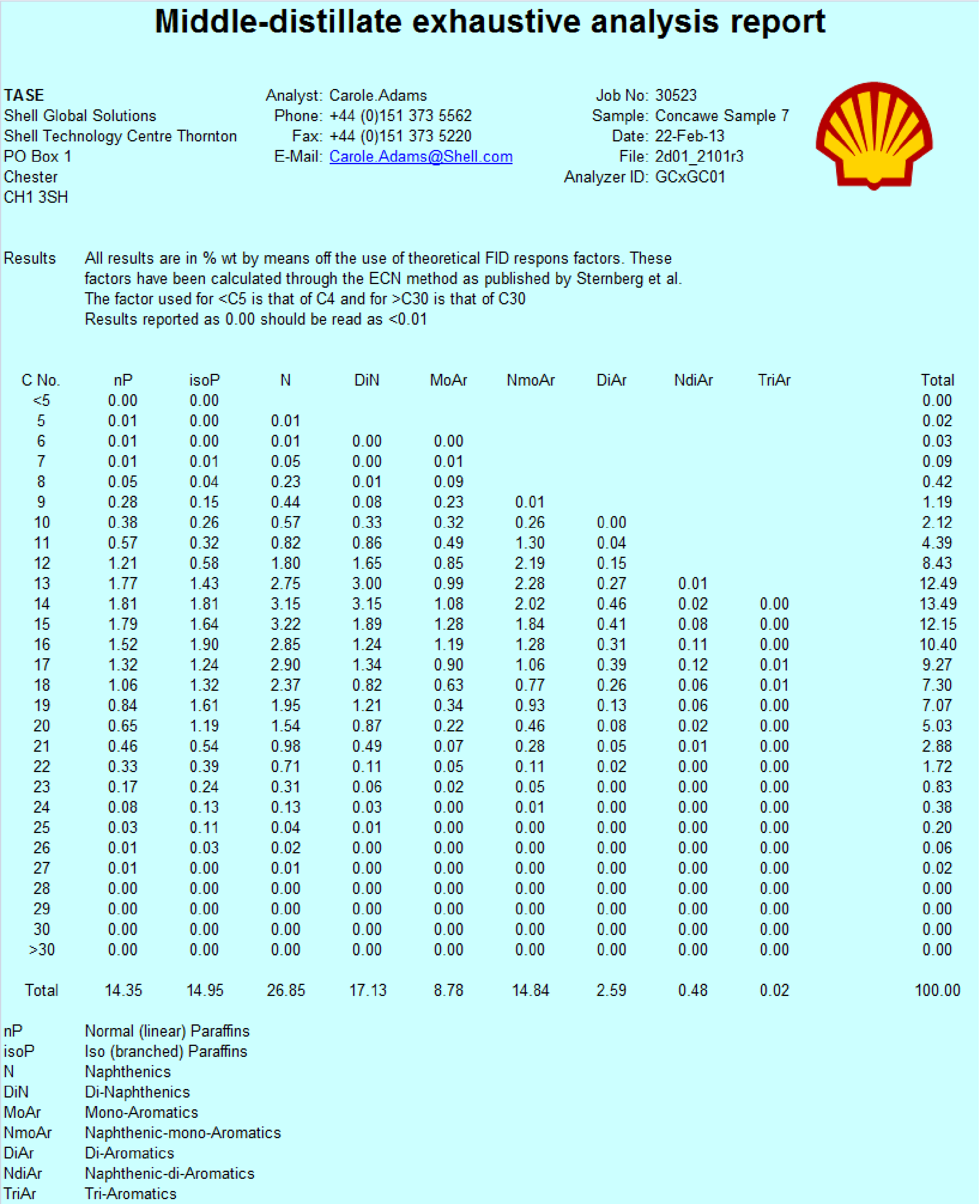
Job No: 30731
Sample: Concawe Sample 6
Date: 11-Apr-13
File: 2d01_0904r5
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.01	0.00	0.53					0.54
9	0.00	0.01	0.05	0.03	6.93	0.23				7.25
10	0.21	0.09	0.60	0.37	3.39	0.91	0.05			5.61
11	0.36	0.50	0.87	0.69	0.85	1.46	0.18			4.91
12	0.34	0.49	1.00	0.66	0.70	1.63	0.31	0.01		5.14
13	0.34	0.60	1.11	0.94	0.85	1.83	0.50	0.09		6.26
14	0.37	0.55	1.18	1.07	0.68	1.87	0.86	0.37	0.02	6.96
15	0.43	0.54	1.28	1.10	0.63	1.94	0.87	0.67	0.10	7.56
16	0.45	0.63	1.22	0.75	0.83	1.62	0.74	0.57	0.13	6.94
17	0.55	0.62	1.46	0.79	0.92	1.94	0.96	0.39	0.20	7.82
18	0.65	0.79	1.44	0.73	0.84	1.36	0.87	0.33	0.15	7.16
19	0.72	0.98	1.44	0.53	1.04	1.51	0.77	0.12	0.06	7.17
20	0.77	0.99	1.64	0.74	1.01	1.29	0.60	0.19	0.00	7.25
21	0.76	0.90	1.43	0.70	0.76	1.10	0.40	0.11	0.00	6.17
22	0.70	0.88	1.26	0.55	0.78	0.74	0.31	0.03	0.00	5.24
23	0.58	0.80	0.93	0.31	0.44	0.42	0.12	0.01	0.00	3.62
24	0.43	0.63	0.58	0.22	0.26	0.18	0.05	0.00	0.00	2.34
25	0.21	0.48	0.32	0.13	0.12	0.04	0.01	0.00	0.00	1.31
26	0.08	0.29	0.10	0.02	0.02	0.02	0.00	0.00	0.00	0.52
27	0.02	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.11
28	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06
29	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
30	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	7.98	10.89	17.96	10.33	21.59	20.10	7.58	2.89	0.66	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 7 (OGO)



Middle-distillate exhaustive analysis report

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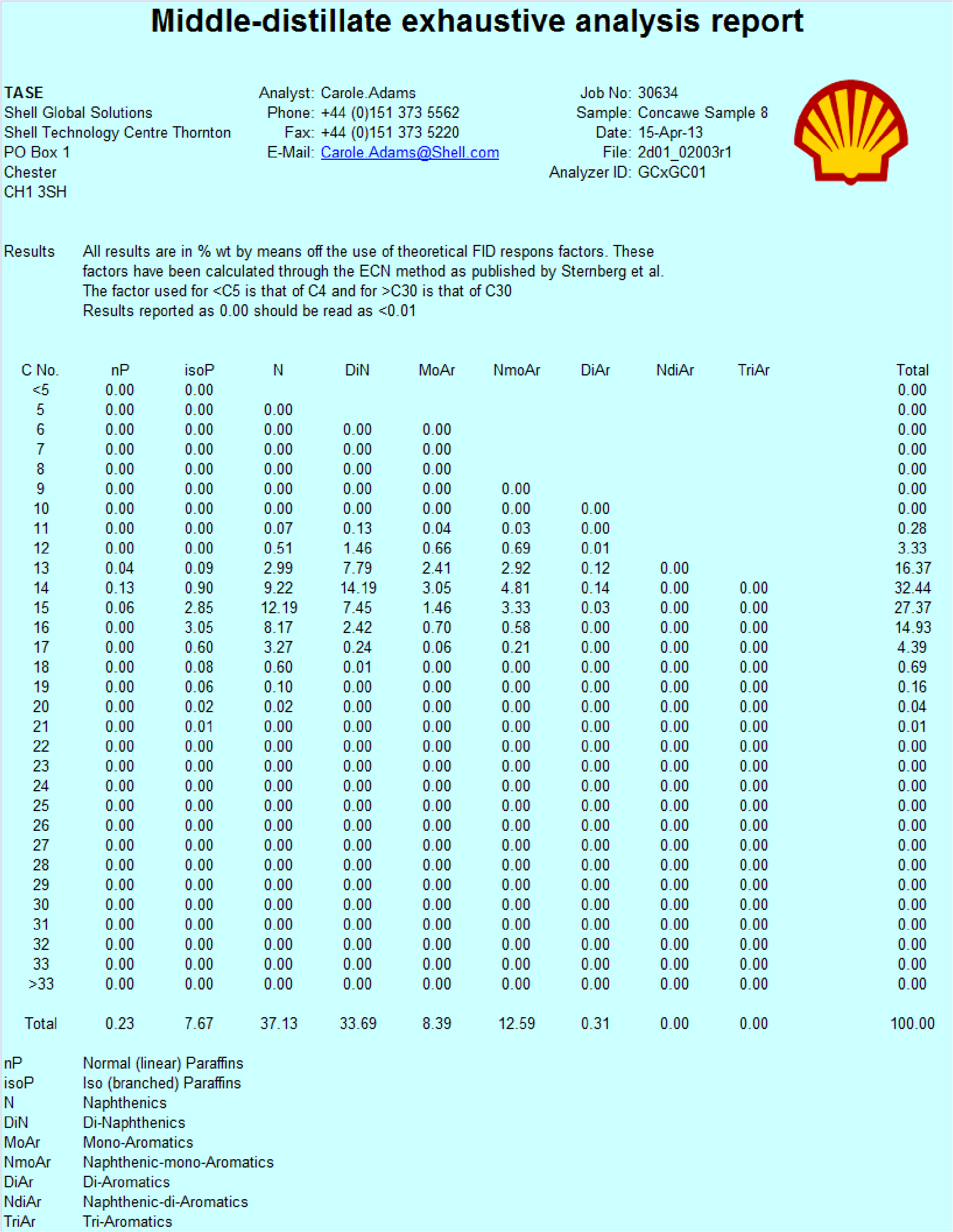
Job No: 30523
Sample: Concawe Sample 7
Date: 22-Feb-13
File: 2d01_2101r3
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.01	0.00	0.01							0.02
6	0.01	0.00	0.01	0.00	0.00					0.03
7	0.01	0.01	0.05	0.00	0.01					0.09
8	0.05	0.04	0.23	0.01	0.09					0.42
9	0.28	0.15	0.44	0.08	0.23	0.01				1.19
10	0.38	0.26	0.57	0.33	0.32	0.26	0.00			2.12
11	0.57	0.32	0.82	0.86	0.49	1.30	0.04			4.39
12	1.21	0.58	1.80	1.65	0.85	2.19	0.15			8.43
13	1.77	1.43	2.75	3.00	0.99	2.28	0.27	0.01		12.49
14	1.81	1.81	3.15	3.15	1.08	2.02	0.46	0.02	0.00	13.49
15	1.79	1.64	3.22	1.89	1.28	1.84	0.41	0.08	0.00	12.15
16	1.52	1.90	2.85	1.24	1.19	1.28	0.31	0.11	0.00	10.40
17	1.32	1.24	2.90	1.34	0.90	1.06	0.39	0.12	0.01	9.27
18	1.06	1.32	2.37	0.82	0.63	0.77	0.26	0.06	0.01	7.30
19	0.84	1.61	1.95	1.21	0.34	0.93	0.13	0.06	0.00	7.07
20	0.65	1.19	1.54	0.87	0.22	0.46	0.08	0.02	0.00	5.03
21	0.46	0.54	0.98	0.49	0.07	0.28	0.05	0.01	0.00	2.88
22	0.33	0.39	0.71	0.11	0.05	0.11	0.02	0.00	0.00	1.72
23	0.17	0.24	0.31	0.06	0.02	0.05	0.00	0.00	0.00	0.83
24	0.08	0.13	0.13	0.03	0.00	0.01	0.00	0.00	0.00	0.38
25	0.03	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.20
26	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.06
27	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	14.35	14.95	26.85	17.13	8.78	14.84	2.59	0.48	0.02	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 8 (OGO)



Middle-distillate exhaustive analysis report

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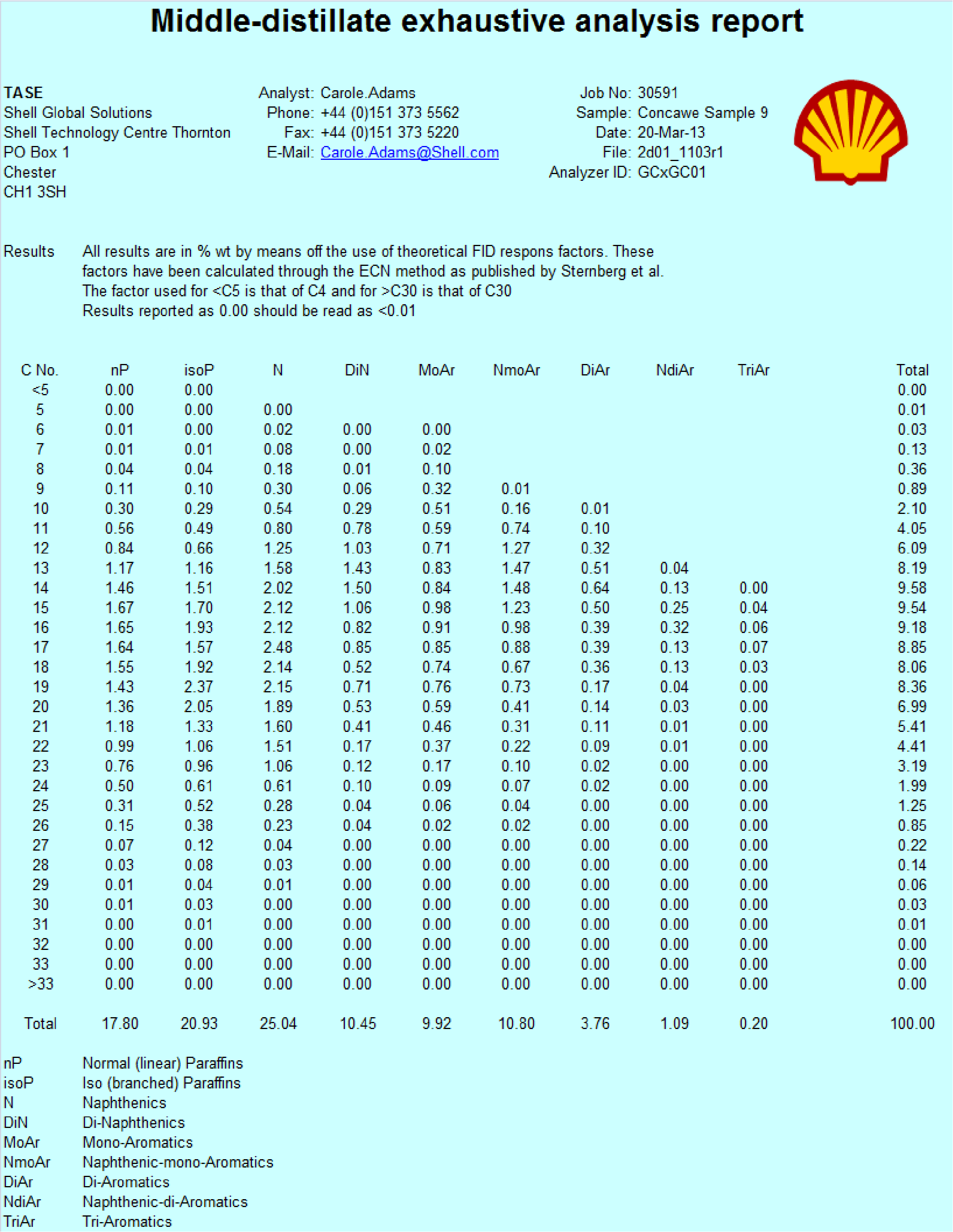
Job No: 30634
Sample: Concawe Sample 8
Date: 15-Apr-13
File: 2d01_02003r1
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.00
9	0.00	0.00	0.00	0.00	0.00	0.00				0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00
11	0.00	0.00	0.07	0.13	0.04	0.03	0.00			0.28
12	0.00	0.00	0.51	1.46	0.66	0.69	0.01			3.33
13	0.04	0.09	2.99	7.79	2.41	2.92	0.12	0.00		16.37
14	0.13	0.90	9.22	14.19	3.05	4.81	0.14	0.00	0.00	32.44
15	0.06	2.85	12.19	7.45	1.46	3.33	0.03	0.00	0.00	27.37
16	0.00	3.05	8.17	2.42	0.70	0.58	0.00	0.00	0.00	14.93
17	0.00	0.60	3.27	0.24	0.06	0.21	0.00	0.00	0.00	4.39
18	0.00	0.08	0.60	0.01	0.00	0.00	0.00	0.00	0.00	0.69
19	0.00	0.06	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.16
20	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04
21	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.23	7.67	37.13	33.69	8.39	12.59	0.31	0.00	0.00	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 9 (OGO)



Middle-distillate exhaustive analysis report

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Job No: 30591
Sample: Concawe Sample 9
Date: 20-Mar-13
File: 2d01_1103r1
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.01
6	0.01	0.00	0.02	0.00	0.00					0.03
7	0.01	0.01	0.08	0.00	0.02					0.13
8	0.04	0.04	0.18	0.01	0.10					0.36
9	0.11	0.10	0.30	0.06	0.32	0.01				0.89
10	0.30	0.29	0.54	0.29	0.51	0.16	0.01			2.10
11	0.56	0.49	0.80	0.78	0.59	0.74	0.10			4.05
12	0.84	0.66	1.25	1.03	0.71	1.27	0.32			6.09
13	1.17	1.16	1.58	1.43	0.83	1.47	0.51	0.04		8.19
14	1.46	1.51	2.02	1.50	0.84	1.48	0.64	0.13	0.00	9.58
15	1.67	1.70	2.12	1.06	0.98	1.23	0.50	0.25	0.04	9.54
16	1.65	1.93	2.12	0.82	0.91	0.98	0.39	0.32	0.06	9.18
17	1.64	1.57	2.48	0.85	0.85	0.88	0.39	0.13	0.07	8.85
18	1.55	1.92	2.14	0.52	0.74	0.67	0.36	0.13	0.03	8.06
19	1.43	2.37	2.15	0.71	0.76	0.73	0.17	0.04	0.00	8.36
20	1.36	2.05	1.89	0.53	0.59	0.41	0.14	0.03	0.00	6.99
21	1.18	1.33	1.60	0.41	0.46	0.31	0.11	0.01	0.00	5.41
22	0.99	1.06	1.51	0.17	0.37	0.22	0.09	0.01	0.00	4.41
23	0.76	0.96	1.06	0.12	0.17	0.10	0.02	0.00	0.00	3.19
24	0.50	0.61	0.61	0.10	0.09	0.07	0.02	0.00	0.00	1.99
25	0.31	0.52	0.28	0.04	0.06	0.04	0.00	0.00	0.00	1.25
26	0.15	0.38	0.23	0.04	0.02	0.02	0.00	0.00	0.00	0.85
27	0.07	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.22
28	0.03	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.14
29	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06
30	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
31	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	17.80	20.93	25.04	10.45	9.92	10.80	3.76	1.09	0.20	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 11 (OGO)

Middle-distillate exhaustive analysis report

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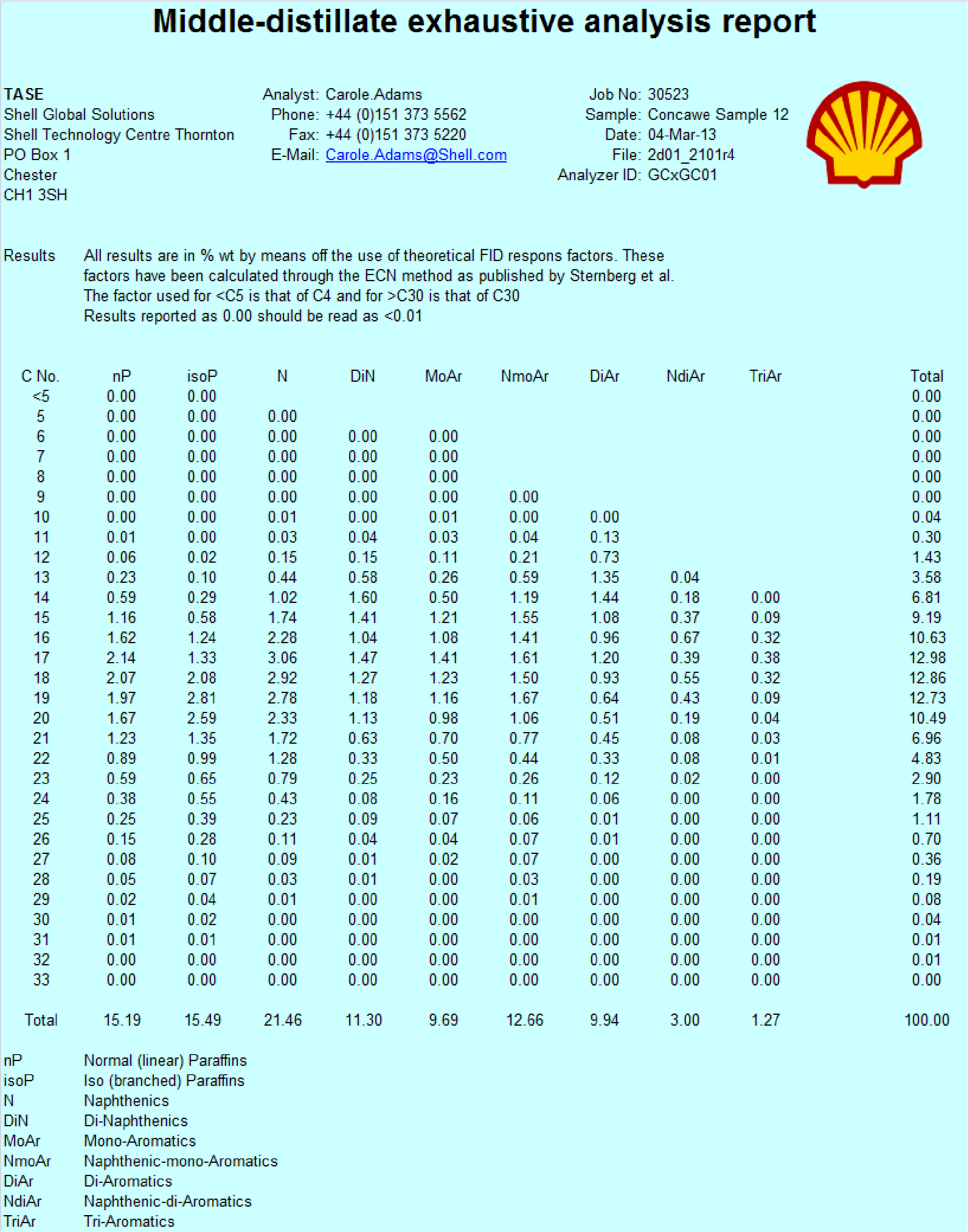
Job No: 30731
Sample: Concawe Sample 11
Date: 19-Apr-13
File: 2d01_1704r1
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.00
9	0.00	0.00	0.00	0.00	0.00	0.00				0.00
10	0.04	0.00	0.00	0.00	0.00	0.00	0.00			0.04
11	0.12	0.00	0.00	0.00	0.00	0.00	0.00			0.12
12	0.12	0.00	0.00	0.00	0.00	0.02	0.34			0.49
13	0.16	0.00	0.05	0.07	0.04	0.48	2.31	0.10		3.22
14	1.76	0.15	1.52	1.74	0.53	1.97	1.03	0.18	0.00	8.88
15	10.87	4.22	5.76	2.28	1.41	1.90	0.35	0.07	0.01	26.87
16	4.15	8.39	5.43	1.37	1.16	1.03	0.09	0.02	0.01	21.65
17	1.66	5.61	3.98	0.63	0.50	0.44	0.04	0.01	0.00	12.87
18	0.73	5.37	2.22	0.26	0.25	0.14	0.01	0.00	0.00	8.97
19	0.44	4.25	1.65	0.09	0.14	0.06	0.02	0.00	0.00	6.65
20	0.29	3.45	1.08	0.04	0.05	0.03	0.00	0.00	0.00	4.93
21	0.19	1.82	0.56	0.01	0.02	0.01	0.00	0.00	0.00	2.61
22	0.09	1.09	0.18	0.01	0.01	0.00	0.00	0.00	0.00	1.37
23	0.04	0.64	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.74
24	0.02	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.26
25	0.01	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.16
26	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
27	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
28	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
29	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
30	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.70	35.51	22.51	6.49	4.11	6.08	4.19	0.38	0.02	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 12 (VHGO)



Middle-distillate exhaustive analysis report

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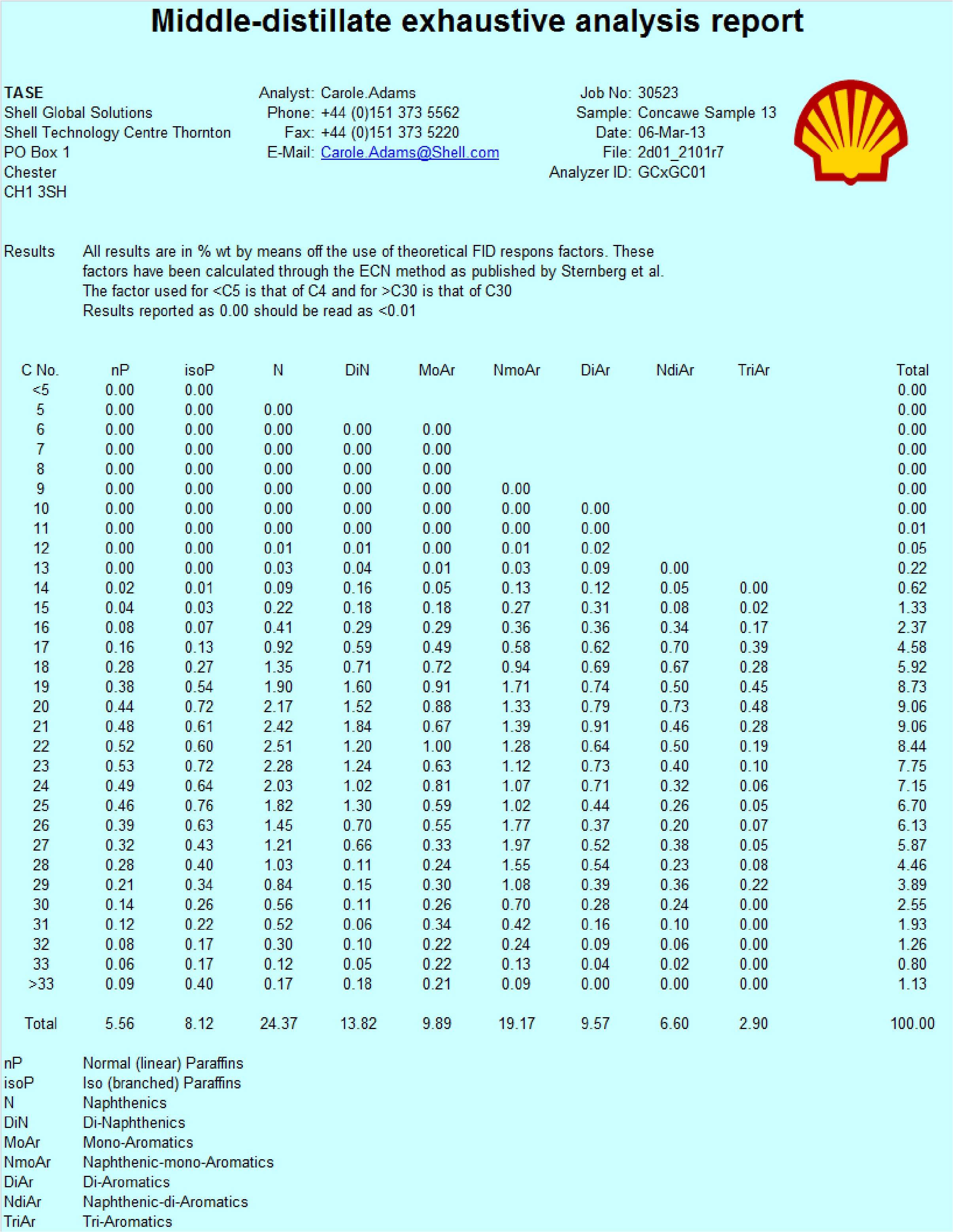
Job No: 30523
Sample: Concawe Sample 12
Date: 04-Mar-13
File: 2d01_2101r4
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.00
9	0.00	0.00	0.00	0.00	0.00	0.00				0.00
10	0.00	0.00	0.01	0.00	0.01	0.00	0.00			0.04
11	0.01	0.00	0.03	0.04	0.03	0.04	0.13			0.30
12	0.06	0.02	0.15	0.15	0.11	0.21	0.73			1.43
13	0.23	0.10	0.44	0.58	0.26	0.59	1.35	0.04		3.58
14	0.59	0.29	1.02	1.60	0.50	1.19	1.44	0.18	0.00	6.81
15	1.16	0.58	1.74	1.41	1.21	1.55	1.08	0.37	0.09	9.19
16	1.62	1.24	2.28	1.04	1.08	1.41	0.96	0.67	0.32	10.63
17	2.14	1.33	3.06	1.47	1.41	1.61	1.20	0.39	0.38	12.98
18	2.07	2.08	2.92	1.27	1.23	1.50	0.93	0.55	0.32	12.86
19	1.97	2.81	2.78	1.18	1.16	1.67	0.64	0.43	0.09	12.73
20	1.67	2.59	2.33	1.13	0.98	1.06	0.51	0.19	0.04	10.49
21	1.23	1.35	1.72	0.63	0.70	0.77	0.45	0.08	0.03	6.96
22	0.89	0.99	1.28	0.33	0.50	0.44	0.33	0.08	0.01	4.83
23	0.59	0.65	0.79	0.25	0.23	0.26	0.12	0.02	0.00	2.90
24	0.38	0.55	0.43	0.08	0.16	0.11	0.06	0.00	0.00	1.78
25	0.25	0.39	0.23	0.09	0.07	0.06	0.01	0.00	0.00	1.11
26	0.15	0.28	0.11	0.04	0.04	0.07	0.01	0.00	0.00	0.70
27	0.08	0.10	0.09	0.01	0.02	0.07	0.00	0.00	0.00	0.36
28	0.05	0.07	0.03	0.01	0.00	0.03	0.00	0.00	0.00	0.19
29	0.02	0.04	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.08
30	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
31	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	15.19	15.49	21.46	11.30	9.69	12.66	9.94	3.00	1.27	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 13 (VHGO)



Middle-distillate exhaustive analysis report

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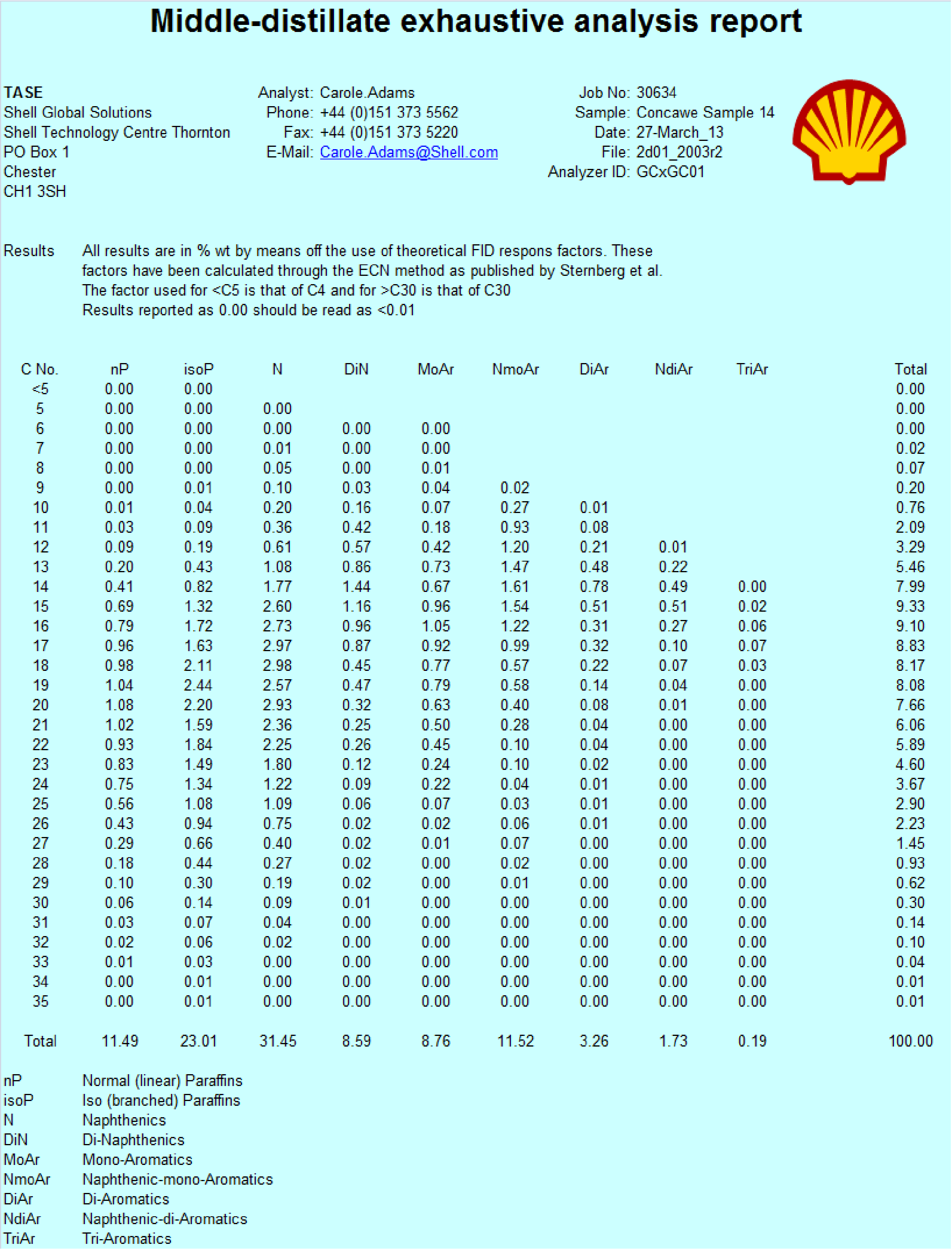
Job No: 30523
Sample: Concawe Sample 13
Date: 06-Mar-13
File: 2d01_2101r7
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.00
9	0.00	0.00	0.00	0.00	0.00	0.00				0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.01
12	0.00	0.00	0.01	0.01	0.00	0.01	0.02			0.05
13	0.00	0.00	0.03	0.04	0.01	0.03	0.09	0.00		0.22
14	0.02	0.01	0.09	0.16	0.05	0.13	0.12	0.05	0.00	0.62
15	0.04	0.03	0.22	0.18	0.18	0.27	0.31	0.08	0.02	1.33
16	0.08	0.07	0.41	0.29	0.29	0.36	0.36	0.34	0.17	2.37
17	0.16	0.13	0.92	0.59	0.49	0.58	0.62	0.70	0.39	4.58
18	0.28	0.27	1.35	0.71	0.72	0.94	0.69	0.67	0.28	5.92
19	0.38	0.54	1.90	1.60	0.91	1.71	0.74	0.50	0.45	8.73
20	0.44	0.72	2.17	1.52	0.88	1.33	0.79	0.73	0.48	9.06
21	0.48	0.61	2.42	1.84	0.67	1.39	0.91	0.46	0.28	9.06
22	0.52	0.60	2.51	1.20	1.00	1.28	0.64	0.50	0.19	8.44
23	0.53	0.72	2.28	1.24	0.63	1.12	0.73	0.40	0.10	7.75
24	0.49	0.64	2.03	1.02	0.81	1.07	0.71	0.32	0.06	7.15
25	0.46	0.76	1.82	1.30	0.59	1.02	0.44	0.26	0.05	6.70
26	0.39	0.63	1.45	0.70	0.55	1.77	0.37	0.20	0.07	6.13
27	0.32	0.43	1.21	0.66	0.33	1.97	0.52	0.38	0.05	5.87
28	0.28	0.40	1.03	0.11	0.24	1.55	0.54	0.23	0.08	4.46
29	0.21	0.34	0.84	0.15	0.30	1.08	0.39	0.36	0.22	3.89
30	0.14	0.26	0.56	0.11	0.26	0.70	0.28	0.24	0.00	2.55
31	0.12	0.22	0.52	0.06	0.34	0.42	0.16	0.10	0.00	1.93
32	0.08	0.17	0.30	0.10	0.22	0.24	0.09	0.06	0.00	1.26
33	0.06	0.17	0.12	0.05	0.22	0.13	0.04	0.02	0.00	0.80
>33	0.09	0.40	0.17	0.18	0.21	0.09	0.00	0.00	0.00	1.13
Total	5.56	8.12	24.37	13.82	9.89	19.17	9.57	6.60	2.90	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 14 (VHGO)



Middle-distillate exhaustive analysis report

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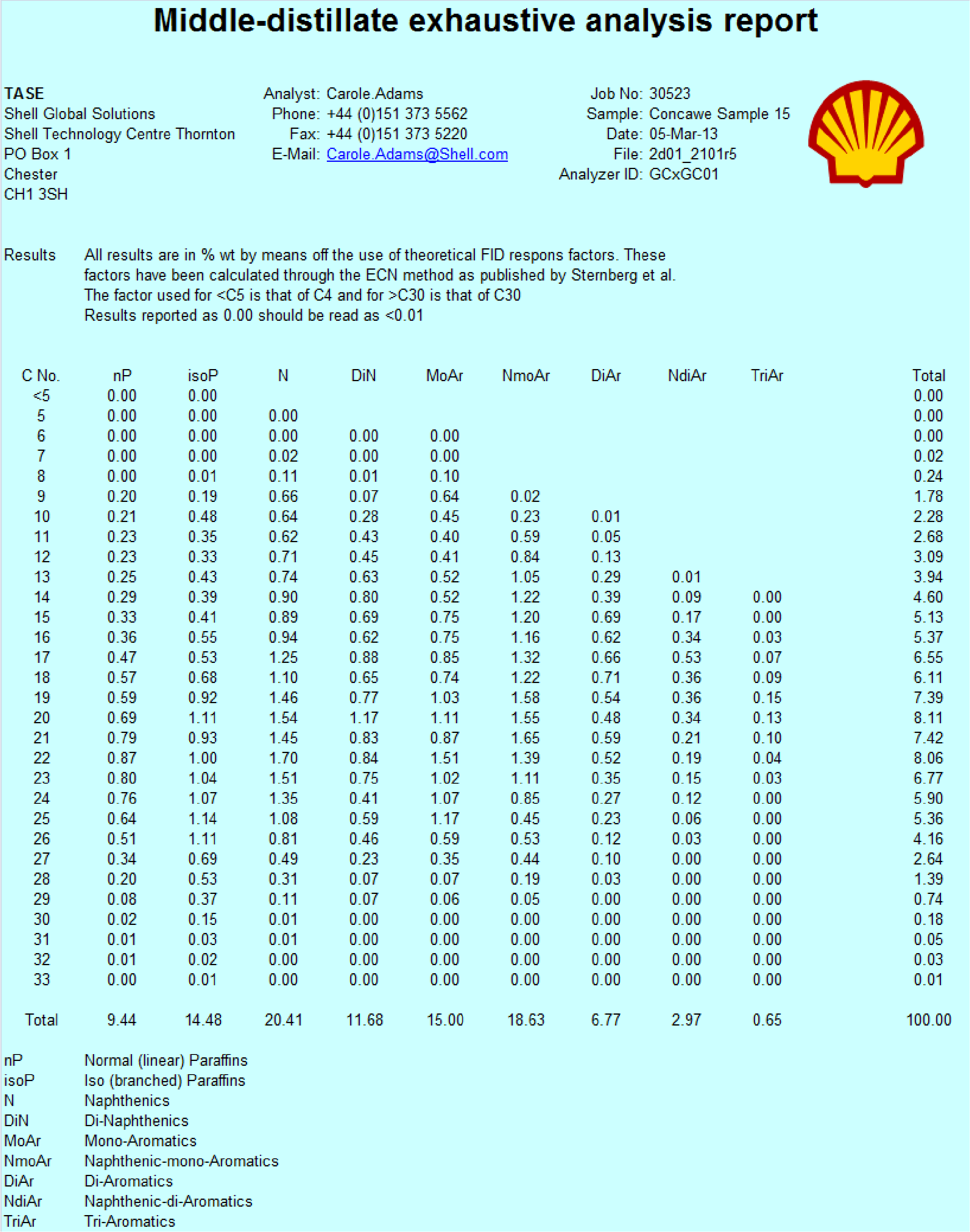
Job No: 30634
Sample: Concawe Sample 14
Date: 27-March_13
File: 2d01_2003r2
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.01	0.00	0.00					0.02
8	0.00	0.00	0.05	0.00	0.01					0.07
9	0.00	0.01	0.10	0.03	0.04	0.02				0.20
10	0.01	0.04	0.20	0.16	0.07	0.27	0.01			0.76
11	0.03	0.09	0.36	0.42	0.18	0.93	0.08			2.09
12	0.09	0.19	0.61	0.57	0.42	1.20	0.21	0.01		3.29
13	0.20	0.43	1.08	0.86	0.73	1.47	0.48	0.22		5.46
14	0.41	0.82	1.77	1.44	0.67	1.61	0.78	0.49	0.00	7.99
15	0.69	1.32	2.60	1.16	0.96	1.54	0.51	0.51	0.02	9.33
16	0.79	1.72	2.73	0.96	1.05	1.22	0.31	0.27	0.06	9.10
17	0.96	1.63	2.97	0.87	0.92	0.99	0.32	0.10	0.07	8.83
18	0.98	2.11	2.98	0.45	0.77	0.57	0.22	0.07	0.03	8.17
19	1.04	2.44	2.57	0.47	0.79	0.58	0.14	0.04	0.00	8.08
20	1.08	2.20	2.93	0.32	0.63	0.40	0.08	0.01	0.00	7.66
21	1.02	1.59	2.36	0.25	0.50	0.28	0.04	0.00	0.00	6.06
22	0.93	1.84	2.25	0.26	0.45	0.10	0.04	0.00	0.00	5.89
23	0.83	1.49	1.80	0.12	0.24	0.10	0.02	0.00	0.00	4.60
24	0.75	1.34	1.22	0.09	0.22	0.04	0.01	0.00	0.00	3.67
25	0.56	1.08	1.09	0.06	0.07	0.03	0.01	0.00	0.00	2.90
26	0.43	0.94	0.75	0.02	0.02	0.06	0.01	0.00	0.00	2.23
27	0.29	0.66	0.40	0.02	0.01	0.07	0.00	0.00	0.00	1.45
28	0.18	0.44	0.27	0.02	0.00	0.02	0.00	0.00	0.00	0.93
29	0.10	0.30	0.19	0.02	0.00	0.01	0.00	0.00	0.00	0.62
30	0.06	0.14	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.30
31	0.03	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.14
32	0.02	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.10
33	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
34	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
35	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	11.49	23.01	31.45	8.59	8.76	11.52	3.26	1.73	0.19	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 15 (VHGO)



Middle-distillate exhaustive analysis report

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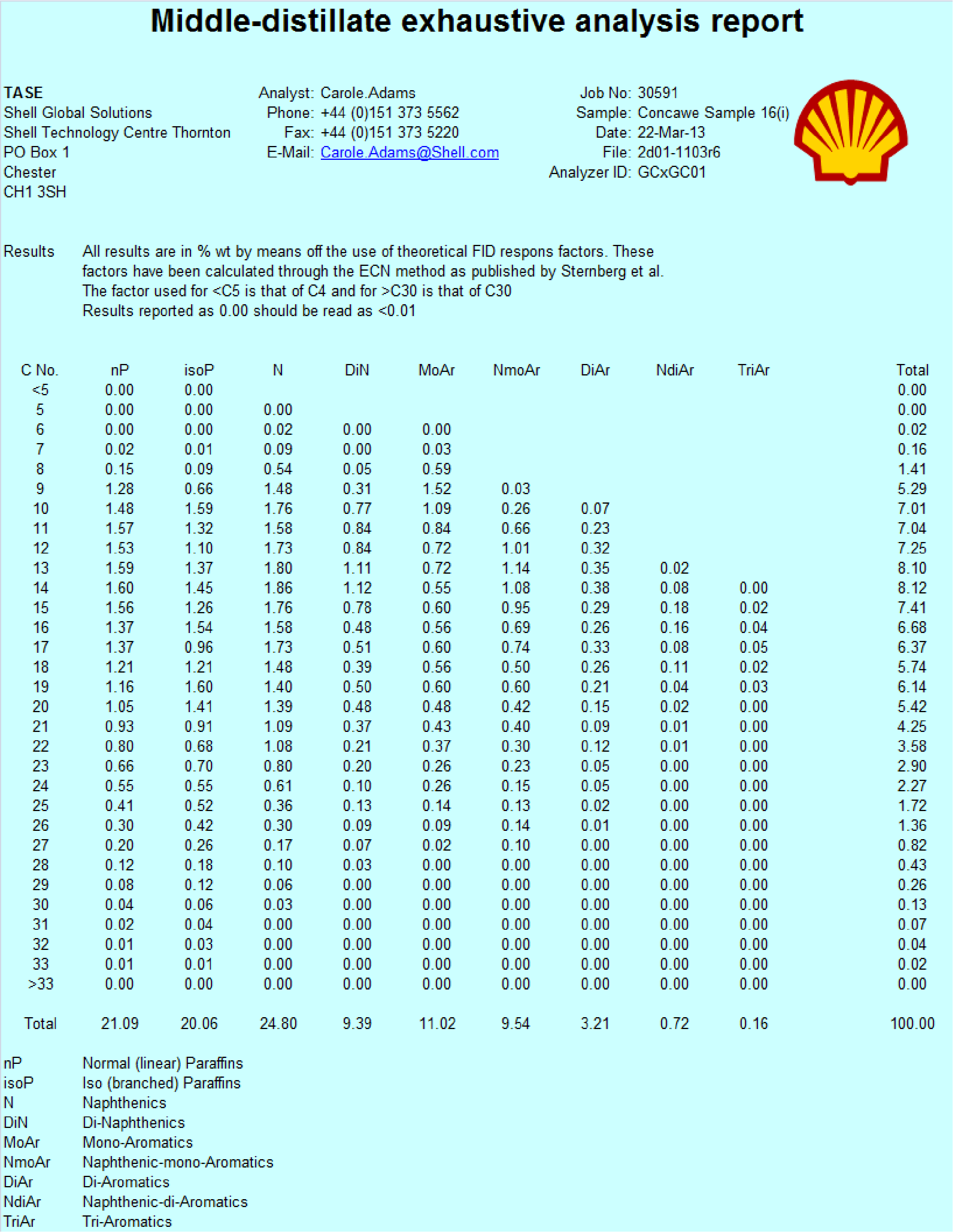
Job No: 30523
Sample: Concawe Sample 15
Date: 05-Mar-13
File: 2d01_2101r5
Analyzer ID: GCxGC01

Results	
	All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30 Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.02	0.00	0.00					0.02
8	0.00	0.01	0.11	0.01	0.10					0.24
9	0.20	0.19	0.66	0.07	0.64	0.02				1.78
10	0.21	0.48	0.64	0.28	0.45	0.23	0.01			2.28
11	0.23	0.35	0.62	0.43	0.40	0.59	0.05			2.68
12	0.23	0.33	0.71	0.45	0.41	0.84	0.13			3.09
13	0.25	0.43	0.74	0.63	0.52	1.05	0.29	0.01		3.94
14	0.29	0.39	0.90	0.80	0.52	1.22	0.39	0.09	0.00	4.60
15	0.33	0.41	0.89	0.69	0.75	1.20	0.69	0.17	0.00	5.13
16	0.36	0.55	0.94	0.62	0.75	1.16	0.62	0.34	0.03	5.37
17	0.47	0.53	1.25	0.88	0.85	1.32	0.66	0.53	0.07	6.55
18	0.57	0.68	1.10	0.65	0.74	1.22	0.71	0.36	0.09	6.11
19	0.59	0.92	1.46	0.77	1.03	1.58	0.54	0.36	0.15	7.39
20	0.69	1.11	1.54	1.17	1.11	1.55	0.48	0.34	0.13	8.11
21	0.79	0.93	1.45	0.83	0.87	1.65	0.59	0.21	0.10	7.42
22	0.87	1.00	1.70	0.84	1.51	1.39	0.52	0.19	0.04	8.06
23	0.80	1.04	1.51	0.75	1.02	1.11	0.35	0.15	0.03	6.77
24	0.76	1.07	1.35	0.41	1.07	0.85	0.27	0.12	0.00	5.90
25	0.64	1.14	1.08	0.59	1.17	0.45	0.23	0.06	0.00	5.36
26	0.51	1.11	0.81	0.46	0.59	0.53	0.12	0.03	0.00	4.16
27	0.34	0.69	0.49	0.23	0.35	0.44	0.10	0.00	0.00	2.64
28	0.20	0.53	0.31	0.07	0.07	0.19	0.03	0.00	0.00	1.39
29	0.08	0.37	0.11	0.07	0.06	0.05	0.00	0.00	0.00	0.74
30	0.02	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.18
31	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05
32	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
33	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	9.44	14.48	20.41	11.68	15.00	18.63	6.77	2.97	0.65	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 16(i) (VHGO)



Middle-distillate exhaustive analysis report

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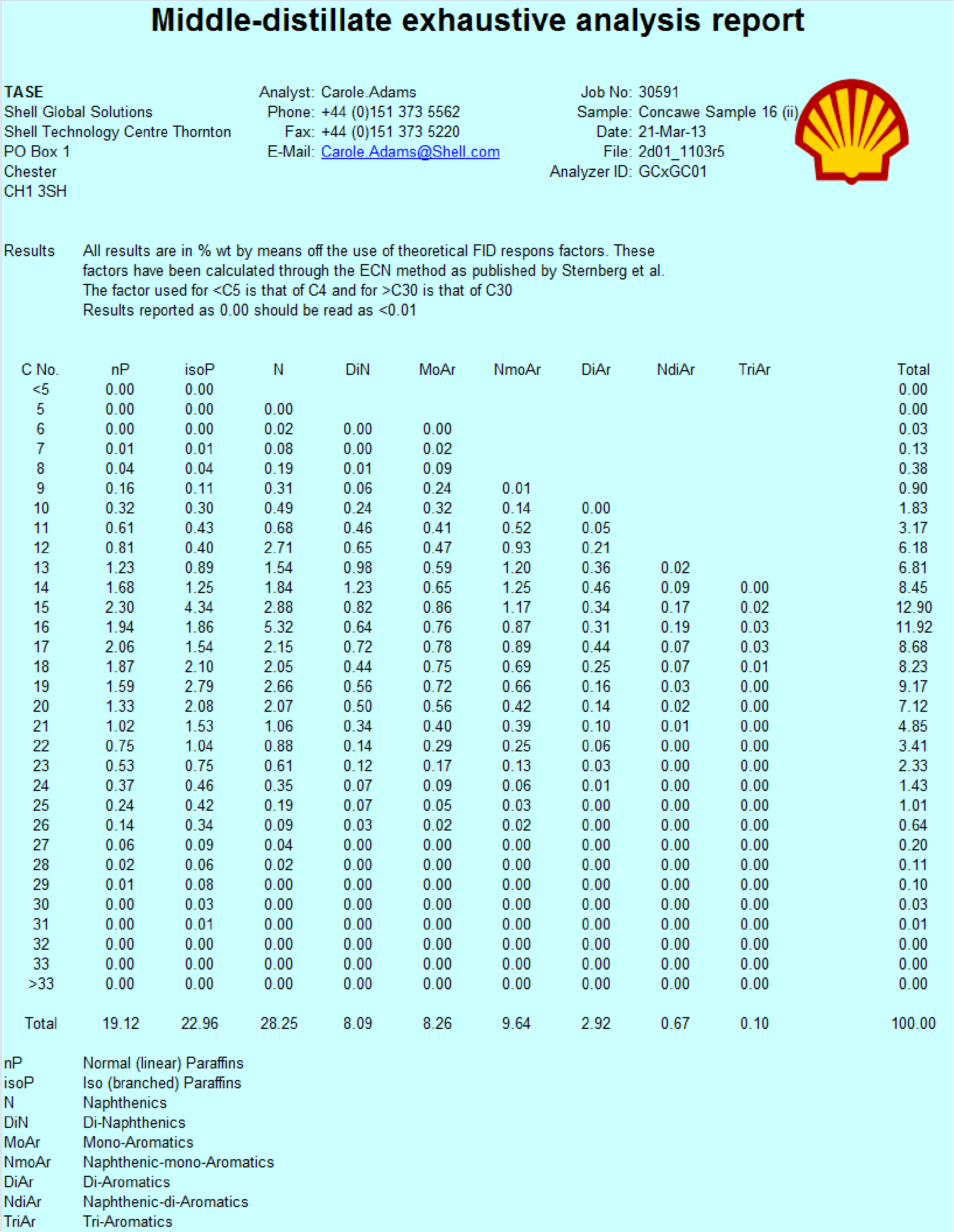
Job No: 30591
Sample: Concawe Sample 16(i)
Date: 22-Mar-13
File: 2d01-1103r6
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.02	0.00	0.00					0.02
7	0.02	0.01	0.09	0.00	0.03					0.16
8	0.15	0.09	0.54	0.05	0.59					1.41
9	1.28	0.66	1.48	0.31	1.52	0.03				5.29
10	1.48	1.59	1.76	0.77	1.09	0.26	0.07			7.01
11	1.57	1.32	1.58	0.84	0.84	0.66	0.23			7.04
12	1.53	1.10	1.73	0.84	0.72	1.01	0.32			7.25
13	1.59	1.37	1.80	1.11	0.72	1.14	0.35	0.02		8.10
14	1.60	1.45	1.86	1.12	0.55	1.08	0.38	0.08	0.00	8.12
15	1.56	1.26	1.76	0.78	0.60	0.95	0.29	0.18	0.02	7.41
16	1.37	1.54	1.58	0.48	0.56	0.69	0.26	0.16	0.04	6.68
17	1.37	0.96	1.73	0.51	0.60	0.74	0.33	0.08	0.05	6.37
18	1.21	1.21	1.48	0.39	0.56	0.50	0.26	0.11	0.02	5.74
19	1.16	1.60	1.40	0.50	0.60	0.60	0.21	0.04	0.03	6.14
20	1.05	1.41	1.39	0.48	0.48	0.42	0.15	0.02	0.00	5.42
21	0.93	0.91	1.09	0.37	0.43	0.40	0.09	0.01	0.00	4.25
22	0.80	0.68	1.08	0.21	0.37	0.30	0.12	0.01	0.00	3.58
23	0.66	0.70	0.80	0.20	0.26	0.23	0.05	0.00	0.00	2.90
24	0.55	0.55	0.61	0.10	0.26	0.15	0.05	0.00	0.00	2.27
25	0.41	0.52	0.36	0.13	0.14	0.13	0.02	0.00	0.00	1.72
26	0.30	0.42	0.30	0.09	0.09	0.14	0.01	0.00	0.00	1.36
27	0.20	0.26	0.17	0.07	0.02	0.10	0.00	0.00	0.00	0.82
28	0.12	0.18	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.43
29	0.08	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.26
30	0.04	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.13
31	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
32	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
33	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	21.09	20.06	24.80	9.39	11.02	9.54	3.21	0.72	0.16	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 16(ii) (VHGO)



Middle-distillate exhaustive analysis report

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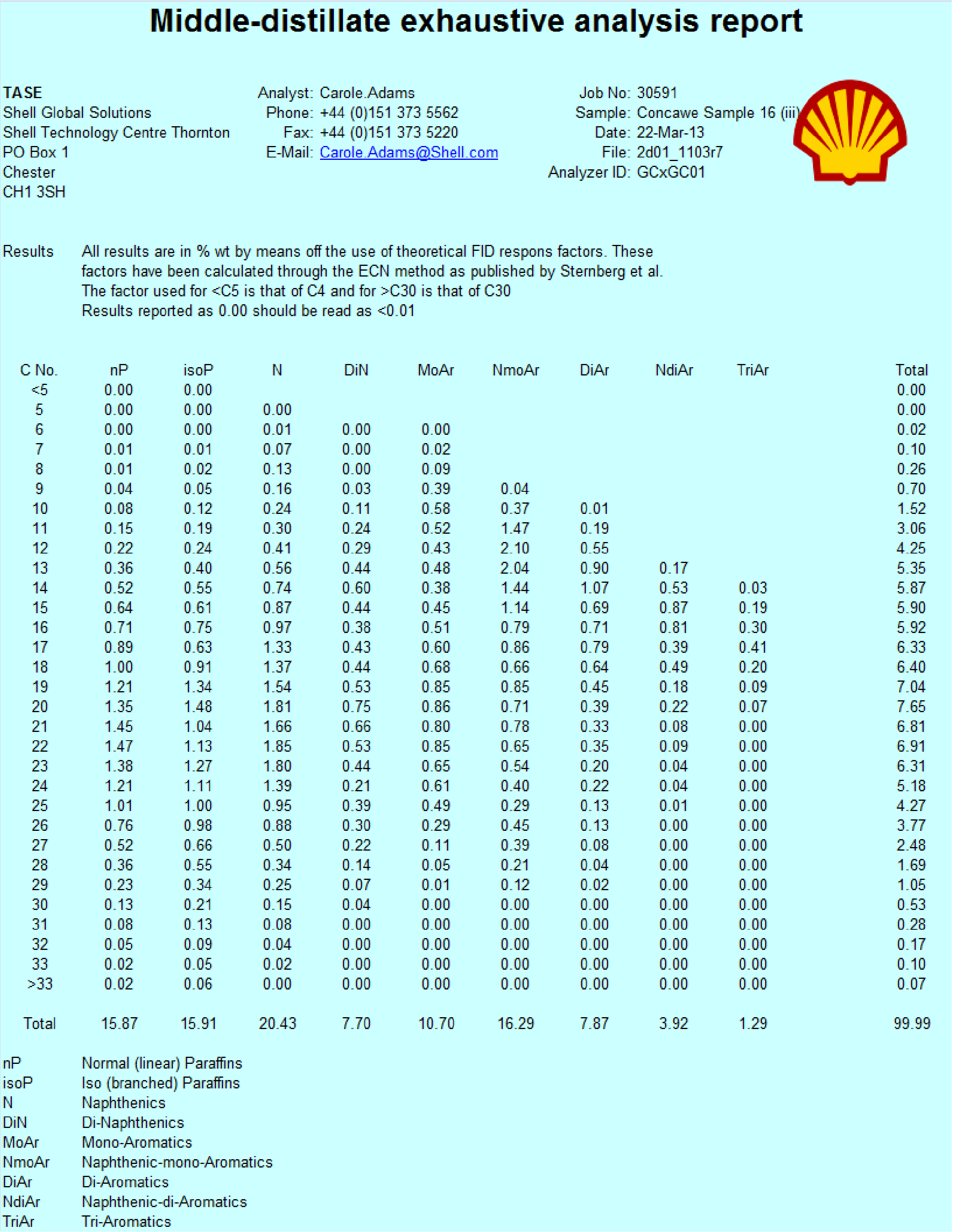
Job No: 30591
Sample: Concawe Sample 16 (ii)
Date: 21-Mar-13
File: 2d01_1103r5
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.02	0.00	0.00					0.03
7	0.01	0.01	0.08	0.00	0.02					0.13
8	0.04	0.04	0.19	0.01	0.09					0.38
9	0.16	0.11	0.31	0.06	0.24	0.01				0.90
10	0.32	0.30	0.49	0.24	0.32	0.14	0.00			1.83
11	0.61	0.43	0.68	0.46	0.41	0.52	0.05			3.17
12	0.81	0.40	2.71	0.65	0.47	0.93	0.21			6.18
13	1.23	0.89	1.54	0.98	0.59	1.20	0.36	0.02		6.81
14	1.68	1.25	1.84	1.23	0.65	1.25	0.46	0.09	0.00	8.45
15	2.30	4.34	2.88	0.82	0.86	1.17	0.34	0.17	0.02	12.90
16	1.94	1.86	5.32	0.64	0.76	0.87	0.31	0.19	0.03	11.92
17	2.06	1.54	2.15	0.72	0.78	0.89	0.44	0.07	0.03	8.68
18	1.87	2.10	2.05	0.44	0.75	0.69	0.25	0.07	0.01	8.23
19	1.59	2.79	2.66	0.56	0.72	0.66	0.16	0.03	0.00	9.17
20	1.33	2.08	2.07	0.50	0.56	0.42	0.14	0.02	0.00	7.12
21	1.02	1.53	1.06	0.34	0.40	0.39	0.10	0.01	0.00	4.85
22	0.75	1.04	0.88	0.14	0.29	0.25	0.06	0.00	0.00	3.41
23	0.53	0.75	0.61	0.12	0.17	0.13	0.03	0.00	0.00	2.33
24	0.37	0.46	0.35	0.07	0.09	0.06	0.01	0.00	0.00	1.43
25	0.24	0.42	0.19	0.07	0.05	0.03	0.00	0.00	0.00	1.01
26	0.14	0.34	0.09	0.03	0.02	0.02	0.00	0.00	0.00	0.64
27	0.06	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.20
28	0.02	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.11
29	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
30	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
31	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	19.12	22.96	28.25	8.09	8.26	9.64	2.92	0.67	0.10	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 16(iii) (VHGO)



Middle-distillate exhaustive analysis report

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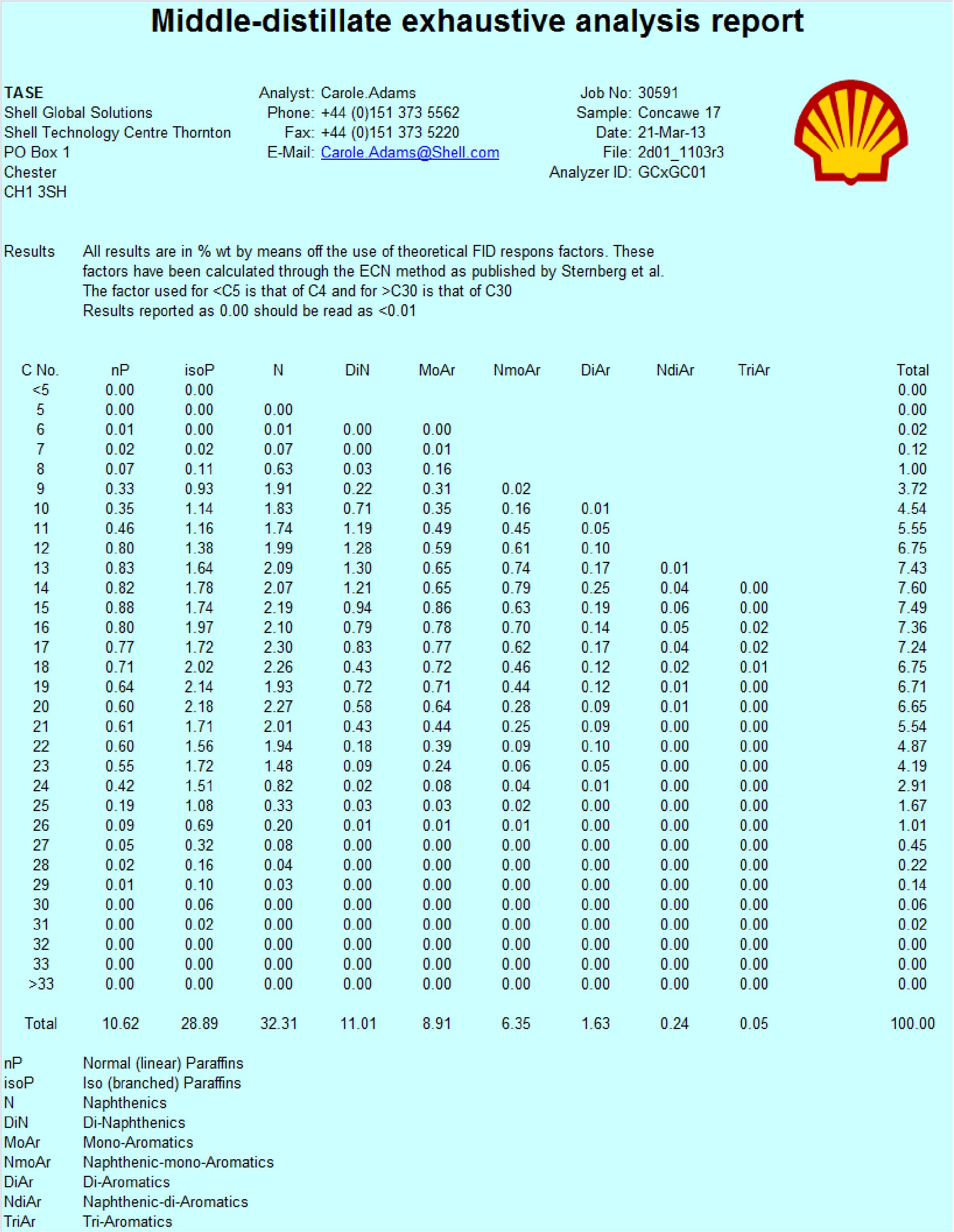
Job No: 30591
Sample: Concawe Sample 16 (iii
Date: 22-Mar-13
File: 2d01_1103r7
Analyzer ID: GCxGC01

Results	All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30 Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.01	0.00	0.00					0.02
7	0.01	0.01	0.07	0.00	0.02					0.10
8	0.01	0.02	0.13	0.00	0.09					0.26
9	0.04	0.05	0.16	0.03	0.39	0.04				0.70
10	0.08	0.12	0.24	0.11	0.58	0.37	0.01			1.52
11	0.15	0.19	0.30	0.24	0.52	1.47	0.19			3.06
12	0.22	0.24	0.41	0.29	0.43	2.10	0.55			4.25
13	0.36	0.40	0.56	0.44	0.48	2.04	0.90	0.17		5.35
14	0.52	0.55	0.74	0.60	0.38	1.44	1.07	0.53	0.03	5.87
15	0.64	0.61	0.87	0.44	0.45	1.14	0.69	0.87	0.19	5.90
16	0.71	0.75	0.97	0.38	0.51	0.79	0.71	0.81	0.30	5.92
17	0.89	0.63	1.33	0.43	0.60	0.86	0.79	0.39	0.41	6.33
18	1.00	0.91	1.37	0.44	0.68	0.66	0.64	0.49	0.20	6.40
19	1.21	1.34	1.54	0.53	0.85	0.85	0.45	0.18	0.09	7.04
20	1.35	1.48	1.81	0.75	0.86	0.71	0.39	0.22	0.07	7.65
21	1.45	1.04	1.66	0.66	0.80	0.78	0.33	0.08	0.00	6.81
22	1.47	1.13	1.85	0.53	0.85	0.65	0.35	0.09	0.00	6.91
23	1.38	1.27	1.80	0.44	0.65	0.54	0.20	0.04	0.00	6.31
24	1.21	1.11	1.39	0.21	0.61	0.40	0.22	0.04	0.00	5.18
25	1.01	1.00	0.95	0.39	0.49	0.29	0.13	0.01	0.00	4.27
26	0.76	0.98	0.88	0.30	0.29	0.45	0.13	0.00	0.00	3.77
27	0.52	0.66	0.50	0.22	0.11	0.39	0.08	0.00	0.00	2.48
28	0.36	0.55	0.34	0.14	0.05	0.21	0.04	0.00	0.00	1.69
29	0.23	0.34	0.25	0.07	0.01	0.12	0.02	0.00	0.00	1.05
30	0.13	0.21	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.53
31	0.08	0.13	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.28
32	0.05	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.17
33	0.02	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.10
>33	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Total	15.87	15.91	20.43	7.70	10.70	16.29	7.87	3.92	1.29	99.99

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 17 (VHGO)



Middle-distillate exhaustive analysis report

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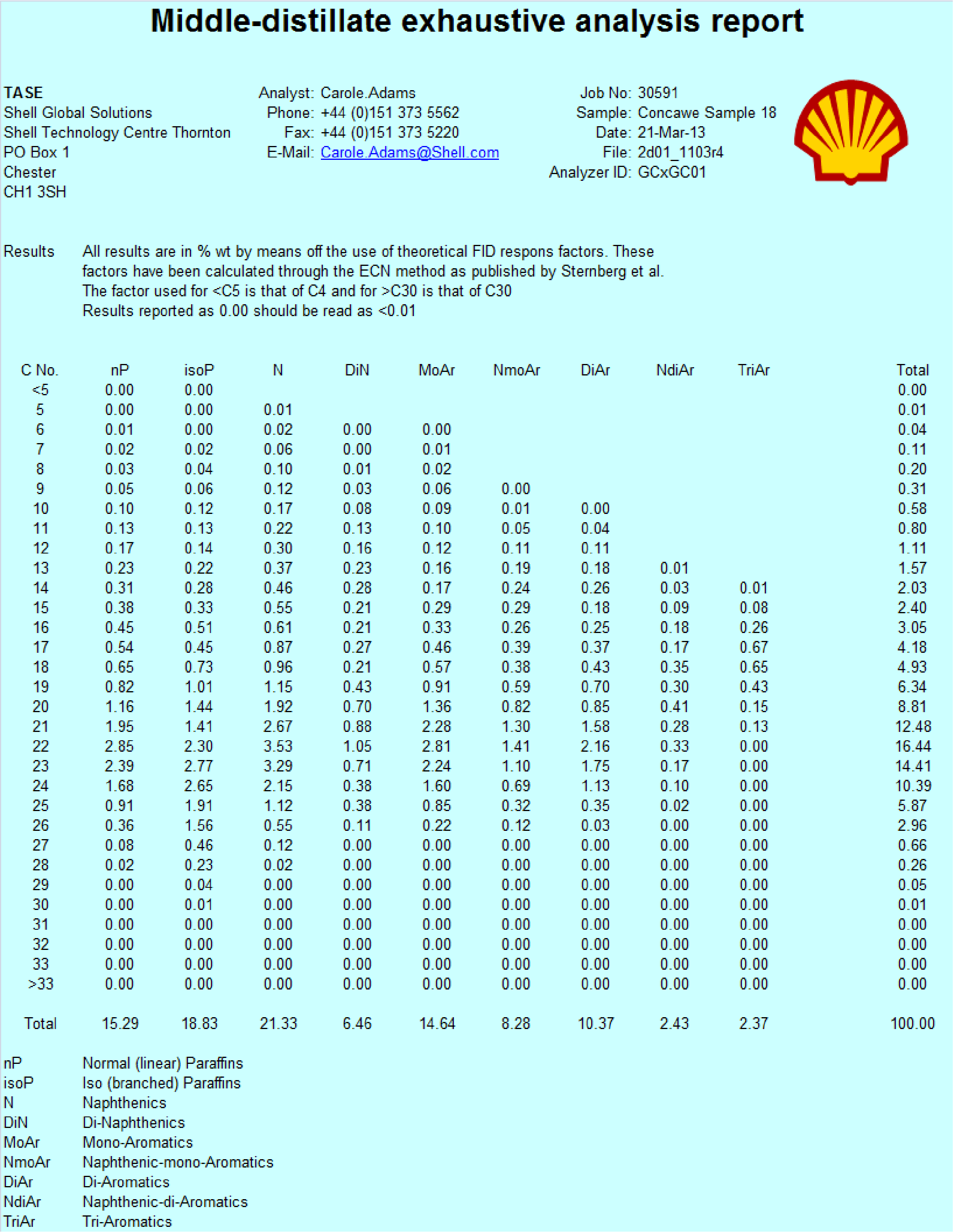
Job No: 30591
Sample: Concawe 17
Date: 21-Mar-13
File: 2d01_1103r3
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.01	0.00	0.01	0.00	0.00					0.02
7	0.02	0.02	0.07	0.00	0.01					0.12
8	0.07	0.11	0.63	0.03	0.16					1.00
9	0.33	0.93	1.91	0.22	0.31	0.02				3.72
10	0.35	1.14	1.83	0.71	0.35	0.16	0.01			4.54
11	0.46	1.16	1.74	1.19	0.49	0.45	0.05			5.55
12	0.80	1.38	1.99	1.28	0.59	0.61	0.10			6.75
13	0.83	1.64	2.09	1.30	0.65	0.74	0.17	0.01		7.43
14	0.82	1.78	2.07	1.21	0.65	0.79	0.25	0.04	0.00	7.60
15	0.88	1.74	2.19	0.94	0.86	0.63	0.19	0.06	0.00	7.49
16	0.80	1.97	2.10	0.79	0.78	0.70	0.14	0.05	0.02	7.36
17	0.77	1.72	2.30	0.83	0.77	0.62	0.17	0.04	0.02	7.24
18	0.71	2.02	2.26	0.43	0.72	0.46	0.12	0.02	0.01	6.75
19	0.64	2.14	1.93	0.72	0.71	0.44	0.12	0.01	0.00	6.71
20	0.60	2.18	2.27	0.58	0.64	0.28	0.09	0.01	0.00	6.65
21	0.61	1.71	2.01	0.43	0.44	0.25	0.09	0.00	0.00	5.54
22	0.60	1.56	1.94	0.18	0.39	0.09	0.10	0.00	0.00	4.87
23	0.55	1.72	1.48	0.09	0.24	0.06	0.05	0.00	0.00	4.19
24	0.42	1.51	0.82	0.02	0.08	0.04	0.01	0.00	0.00	2.91
25	0.19	1.08	0.33	0.03	0.03	0.02	0.00	0.00	0.00	1.67
26	0.09	0.69	0.20	0.01	0.01	0.01	0.00	0.00	0.00	1.01
27	0.05	0.32	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.45
28	0.02	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.22
29	0.01	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.14
30	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
31	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.62	28.89	32.31	11.01	8.91	6.35	1.63	0.24	0.05	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 18 (VHGO)



Middle-distillate exhaustive analysis report

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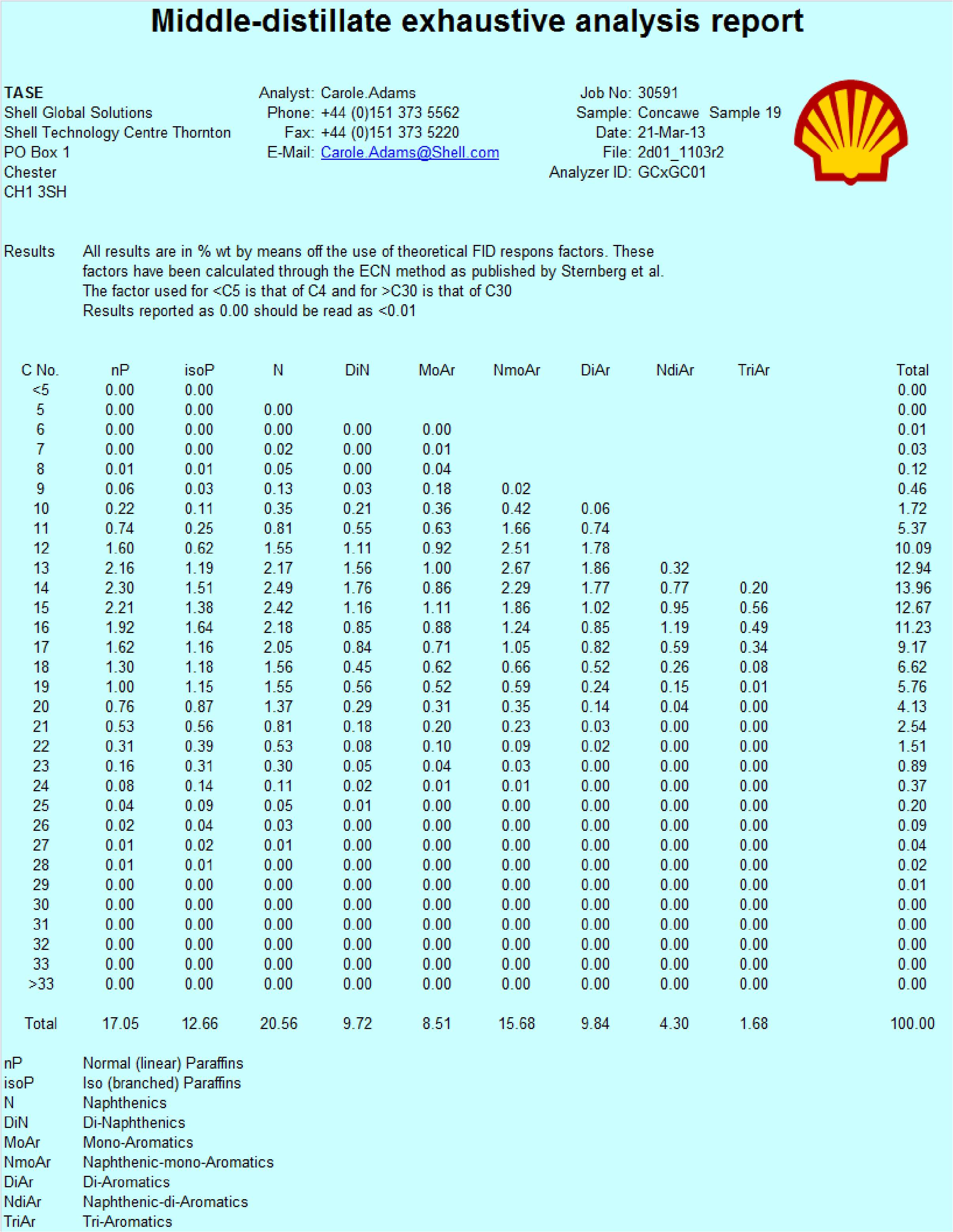
Job No: 30591
Sample: Concawe Sample 18
Date: 21-Mar-13
File: 2d01_1103r4
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al.
The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.01							0.01
6	0.01	0.00	0.02	0.00	0.00					0.04
7	0.02	0.02	0.06	0.00	0.01					0.11
8	0.03	0.04	0.10	0.01	0.02					0.20
9	0.05	0.06	0.12	0.03	0.06	0.00				0.31
10	0.10	0.12	0.17	0.08	0.09	0.01	0.00			0.58
11	0.13	0.13	0.22	0.13	0.10	0.05	0.04			0.80
12	0.17	0.14	0.30	0.16	0.12	0.11	0.11			1.11
13	0.23	0.22	0.37	0.23	0.16	0.19	0.18	0.01		1.57
14	0.31	0.28	0.46	0.28	0.17	0.24	0.26	0.03	0.01	2.03
15	0.38	0.33	0.55	0.21	0.29	0.29	0.18	0.09	0.08	2.40
16	0.45	0.51	0.61	0.21	0.33	0.26	0.25	0.18	0.26	3.05
17	0.54	0.45	0.87	0.27	0.46	0.39	0.37	0.17	0.67	4.18
18	0.65	0.73	0.96	0.21	0.57	0.38	0.43	0.35	0.65	4.93
19	0.82	1.01	1.15	0.43	0.91	0.59	0.70	0.30	0.43	6.34
20	1.16	1.44	1.92	0.70	1.36	0.82	0.85	0.41	0.15	8.81
21	1.95	1.41	2.67	0.88	2.28	1.30	1.58	0.28	0.13	12.48
22	2.85	2.30	3.53	1.05	2.81	1.41	2.16	0.33	0.00	16.44
23	2.39	2.77	3.29	0.71	2.24	1.10	1.75	0.17	0.00	14.41
24	1.68	2.65	2.15	0.38	1.60	0.69	1.13	0.10	0.00	10.39
25	0.91	1.91	1.12	0.38	0.85	0.32	0.35	0.02	0.00	5.87
26	0.36	1.56	0.55	0.11	0.22	0.12	0.03	0.00	0.00	2.96
27	0.08	0.46	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.66
28	0.02	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.26
29	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
30	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	15.29	18.83	21.33	6.46	14.64	8.28	10.37	2.43	2.37	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 19 (VHGO)



Middle-distillate exhaustive analysis report

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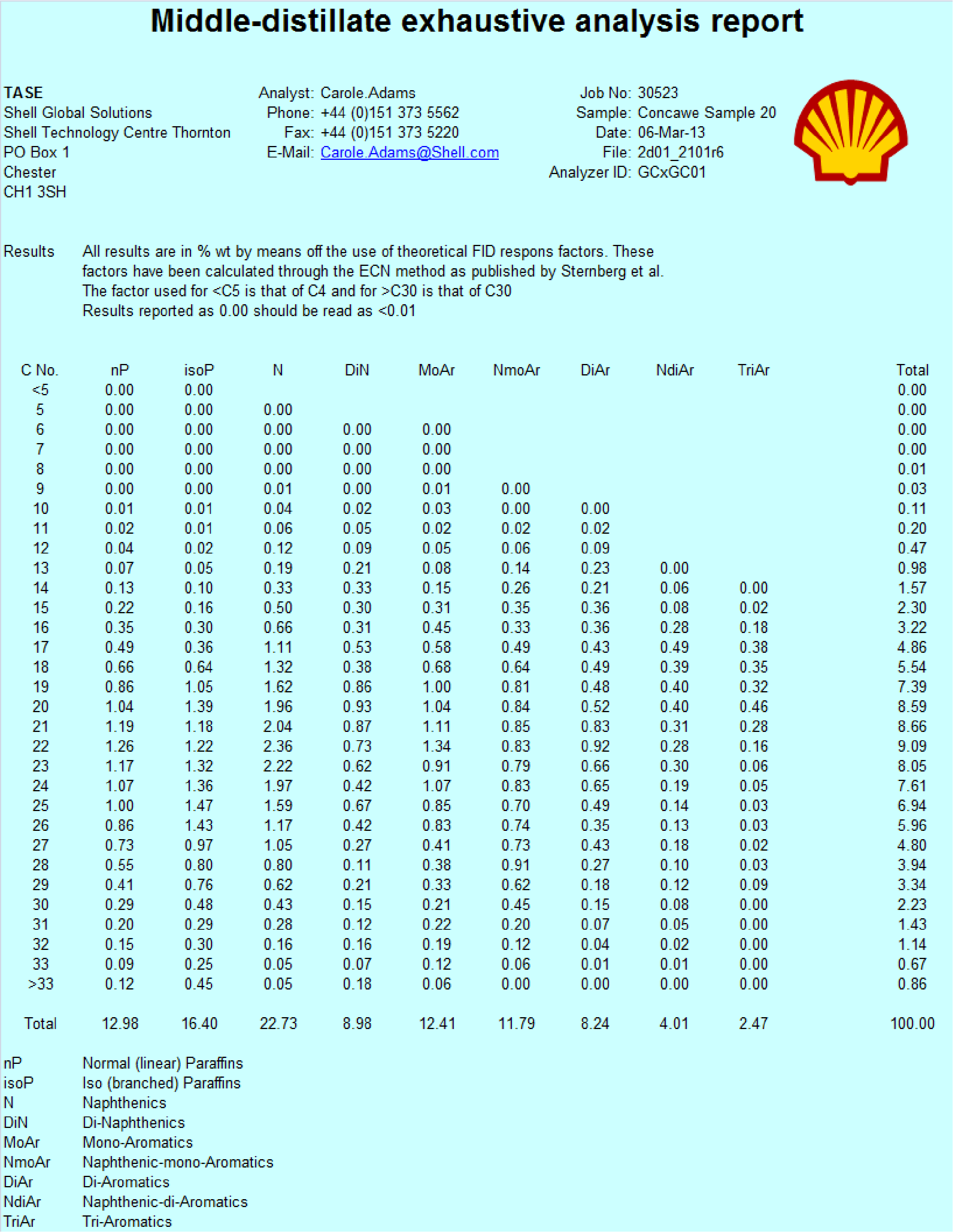
Job No: 30591
Sample: Concawe Sample 19
Date: 21-Mar-13
File: 2d01_1103r2
Analyzer ID: GCxGC01

Results All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30
Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.01
7	0.00	0.00	0.02	0.00	0.01					0.03
8	0.01	0.01	0.05	0.00	0.04					0.12
9	0.06	0.03	0.13	0.03	0.18	0.02				0.46
10	0.22	0.11	0.35	0.21	0.36	0.42	0.06			1.72
11	0.74	0.25	0.81	0.55	0.63	1.66	0.74			5.37
12	1.60	0.62	1.55	1.11	0.92	2.51	1.78			10.09
13	2.16	1.19	2.17	1.56	1.00	2.67	1.86	0.32		12.94
14	2.30	1.51	2.49	1.76	0.86	2.29	1.77	0.77	0.20	13.96
15	2.21	1.38	2.42	1.16	1.11	1.86	1.02	0.95	0.56	12.67
16	1.92	1.64	2.18	0.85	0.88	1.24	0.85	1.19	0.49	11.23
17	1.62	1.16	2.05	0.84	0.71	1.05	0.82	0.59	0.34	9.17
18	1.30	1.18	1.56	0.45	0.62	0.66	0.52	0.26	0.08	6.62
19	1.00	1.15	1.55	0.56	0.52	0.59	0.24	0.15	0.01	5.76
20	0.76	0.87	1.37	0.29	0.31	0.35	0.14	0.04	0.00	4.13
21	0.53	0.56	0.81	0.18	0.20	0.23	0.03	0.00	0.00	2.54
22	0.31	0.39	0.53	0.08	0.10	0.09	0.02	0.00	0.00	1.51
23	0.16	0.31	0.30	0.05	0.04	0.03	0.00	0.00	0.00	0.89
24	0.08	0.14	0.11	0.02	0.01	0.01	0.00	0.00	0.00	0.37
25	0.04	0.09	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.20
26	0.02	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.09
27	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04
28	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	17.05	12.66	20.56	9.72	8.51	15.68	9.84	4.30	1.68	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

CON 20 (VHGO)



Middle-distillate exhaustive analysis report

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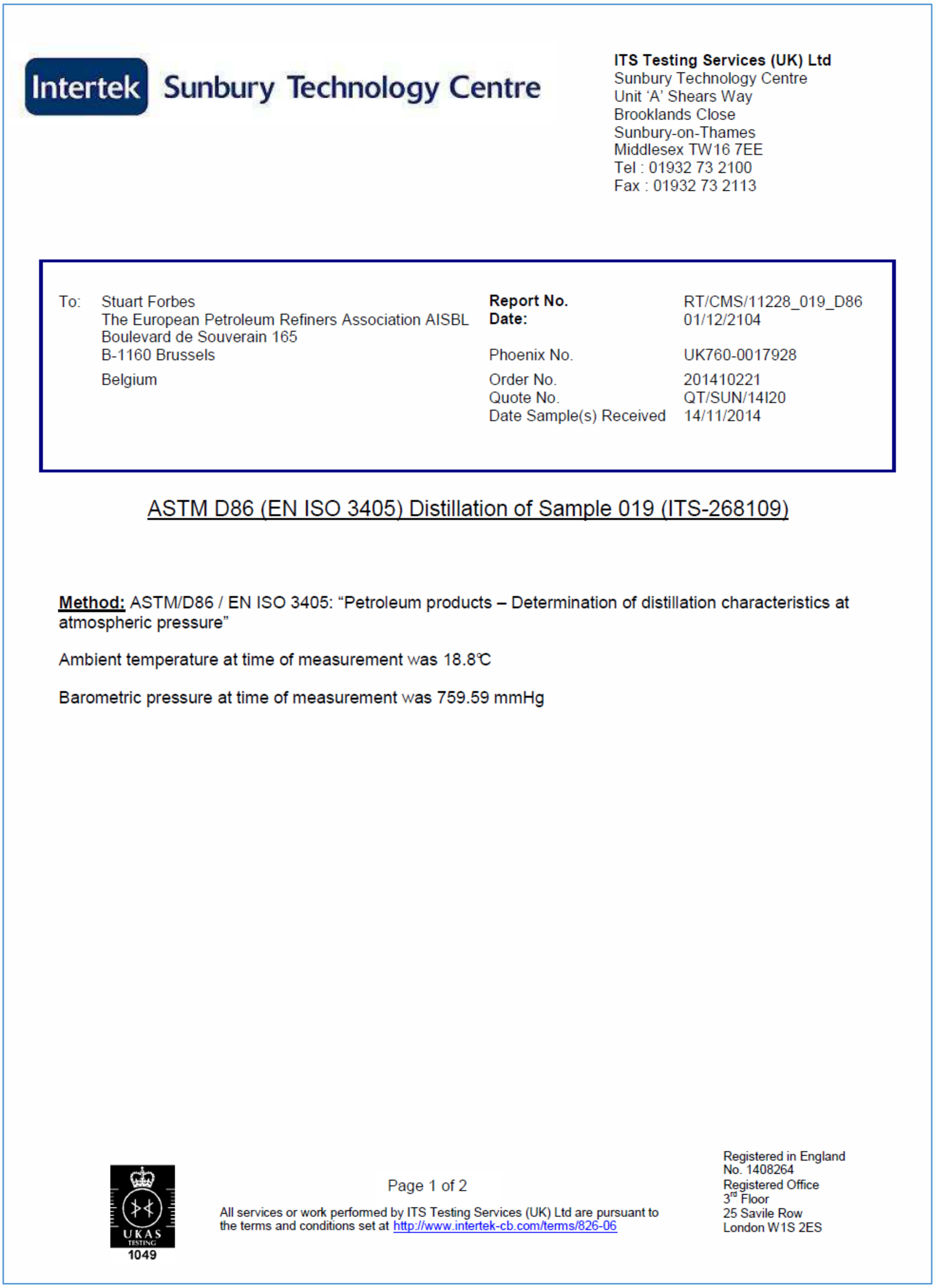
Job No: 30523
Sample: Concawe Sample 20
Date: 06-Mar-13
File: 2d01_2101r6
Analyzer ID: GCxGC01

Results	All results are in % wt by means off the use of theoretical FID respons factors. These factors have been calculated through the ECN method as published by Sternberg et al. The factor used for <C5 is that of C4 and for >C30 is that of C30 Results reported as 0.00 should be read as <0.01

C No.	nP	isoP	N	DiN	MoAr	NmoAr	DiAr	NdiAr	TriAr	Total
<5	0.00	0.00								0.00
5	0.00	0.00	0.00							0.00
6	0.00	0.00	0.00	0.00	0.00					0.00
7	0.00	0.00	0.00	0.00	0.00					0.00
8	0.00	0.00	0.00	0.00	0.00					0.01
9	0.00	0.00	0.01	0.00	0.01	0.00				0.03
10	0.01	0.01	0.04	0.02	0.03	0.00	0.00			0.11
11	0.02	0.01	0.06	0.05	0.02	0.02	0.02			0.20
12	0.04	0.02	0.12	0.09	0.05	0.06	0.09			0.47
13	0.07	0.05	0.19	0.21	0.08	0.14	0.23	0.00		0.98
14	0.13	0.10	0.33	0.33	0.15	0.26	0.21	0.06	0.00	1.57
15	0.22	0.16	0.50	0.30	0.31	0.35	0.36	0.08	0.02	2.30
16	0.35	0.30	0.66	0.31	0.45	0.33	0.36	0.28	0.18	3.22
17	0.49	0.36	1.11	0.53	0.58	0.49	0.43	0.49	0.38	4.86
18	0.66	0.64	1.32	0.38	0.68	0.64	0.49	0.39	0.35	5.54
19	0.86	1.05	1.62	0.86	1.00	0.81	0.48	0.40	0.32	7.39
20	1.04	1.39	1.96	0.93	1.04	0.84	0.52	0.40	0.46	8.59
21	1.19	1.18	2.04	0.87	1.11	0.85	0.83	0.31	0.28	8.66
22	1.26	1.22	2.36	0.73	1.34	0.83	0.92	0.28	0.16	9.09
23	1.17	1.32	2.22	0.62	0.91	0.79	0.66	0.30	0.06	8.05
24	1.07	1.36	1.97	0.42	1.07	0.83	0.65	0.19	0.05	7.61
25	1.00	1.47	1.59	0.67	0.85	0.70	0.49	0.14	0.03	6.94
26	0.86	1.43	1.17	0.42	0.83	0.74	0.35	0.13	0.03	5.96
27	0.73	0.97	1.05	0.27	0.41	0.73	0.43	0.18	0.02	4.80
28	0.55	0.80	0.80	0.11	0.38	0.91	0.27	0.10	0.03	3.94
29	0.41	0.76	0.62	0.21	0.33	0.62	0.18	0.12	0.09	3.34
30	0.29	0.48	0.43	0.15	0.21	0.45	0.15	0.08	0.00	2.23
31	0.20	0.29	0.28	0.12	0.22	0.20	0.07	0.05	0.00	1.43
32	0.15	0.30	0.16	0.16	0.19	0.12	0.04	0.02	0.00	1.14
33	0.09	0.25	0.05	0.07	0.12	0.06	0.01	0.01	0.00	0.67
>33	0.12	0.45	0.05	0.18	0.06	0.00	0.00	0.00	0.00	0.86
Total	12.98	16.40	22.73	8.98	12.41	11.79	8.24	4.01	2.47	100.00

nP	Normal (linear) Paraffins
isoP	Iso (branched) Paraffins
N	Naphthenics
DiN	Di-Naphthenics
MoAr	Mono-Aromatics
NmoAr	Naphthenic-mono-Aromatics
DiAr	Di-Aromatics
NdiAr	Naphthenic-di-Aromatics
TriAr	Tri-Aromatics

APPENDIX 2 – EXAMPLE OF PHYSICAL DISTILLATION REPORT (SAMPLE 019 - LBPN)



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To:
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B-1160 Brussels
Belgium

Report No.	RT/CMS/11228_019_D86
Date:	01/12/2104
Phoenix No.	UK760-0017928
Order No.	201410221
Quote No.	QT/SUN/14I20
Date Sample(s) Received	14/11/2014

ASTM D86 (EN ISO 3405) Distillation of Sample 019 (ITS-268109)

Method: ASTM/D86 / EN ISO 3405: "Petroleum products – Determination of distillation characteristics at atmospheric pressure"

Ambient temperature at time of measurement was 18.8℃

Barometric pressure at time of measurement was 759.59 mmHg

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Page 1 of 2

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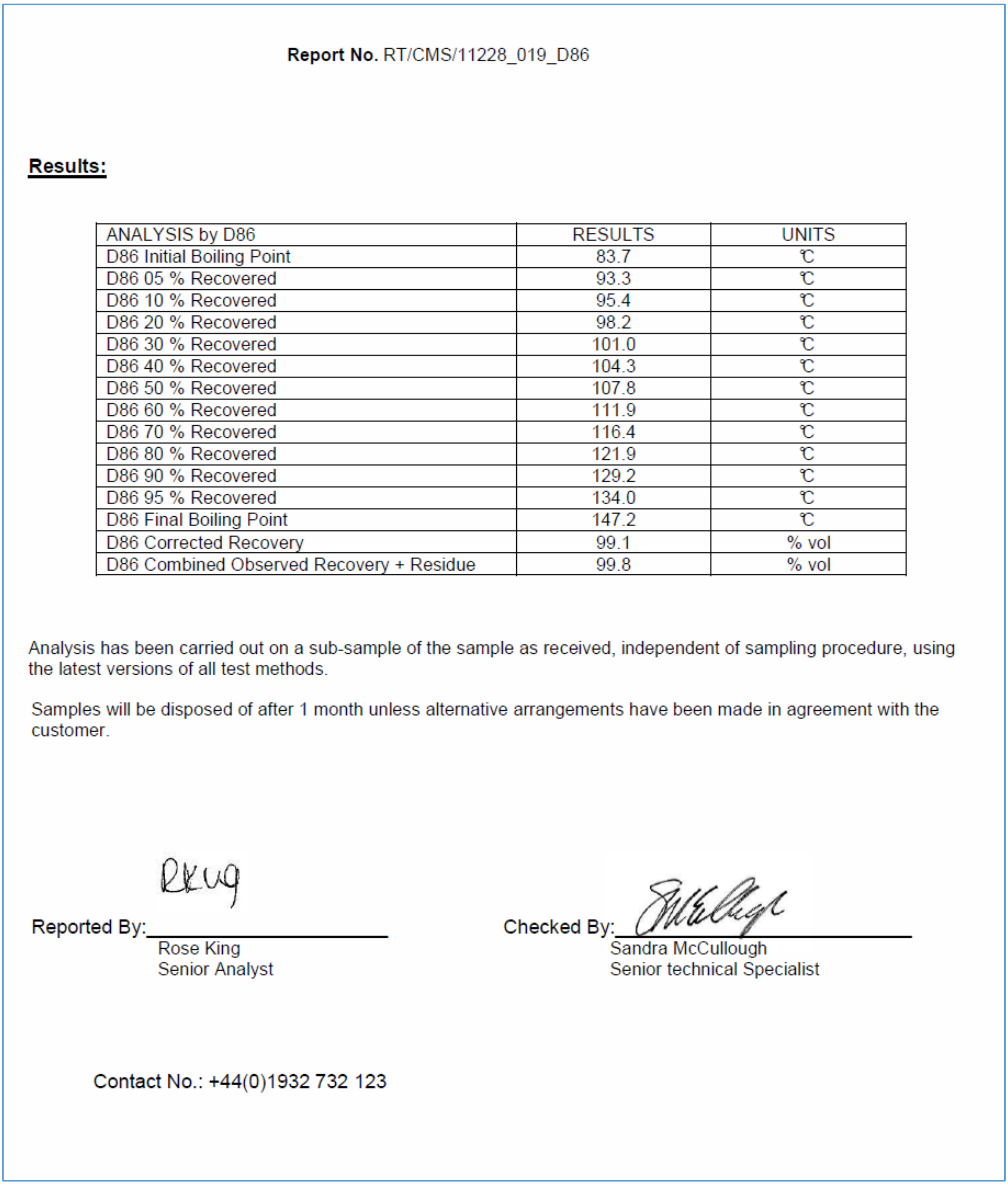


Report No. RT/CMS/11228_019_D86

Results:

ANALYSIS by D86	RESULTS	UNITS
D86 Initial Boiling Point	83.7	℃
D86 05 % Recovered	93.3	℃
D86 10 % Recovered	95.4	℃
D86 20 % Recovered	98.2	℃
D86 30 % Recovered	101.0	℃
D86 40 % Recovered	104.3	℃
D86 50 % Recovered	107.8	℃
D86 60 % Recovered	111.9	℃
D86 70 % Recovered	116.4	℃
D86 80 % Recovered	121.9	℃
D86 90 % Recovered	129.2	℃
D86 95 % Recovered	134.0	℃
D86 Final Boiling Point	147.2	℃
D86 Corrected Recovery	99.1	% vol
D86 Combined Observed Recovery + Residue	99.8	% vol

Analysis has been carried out on a sub-sample of the sample as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

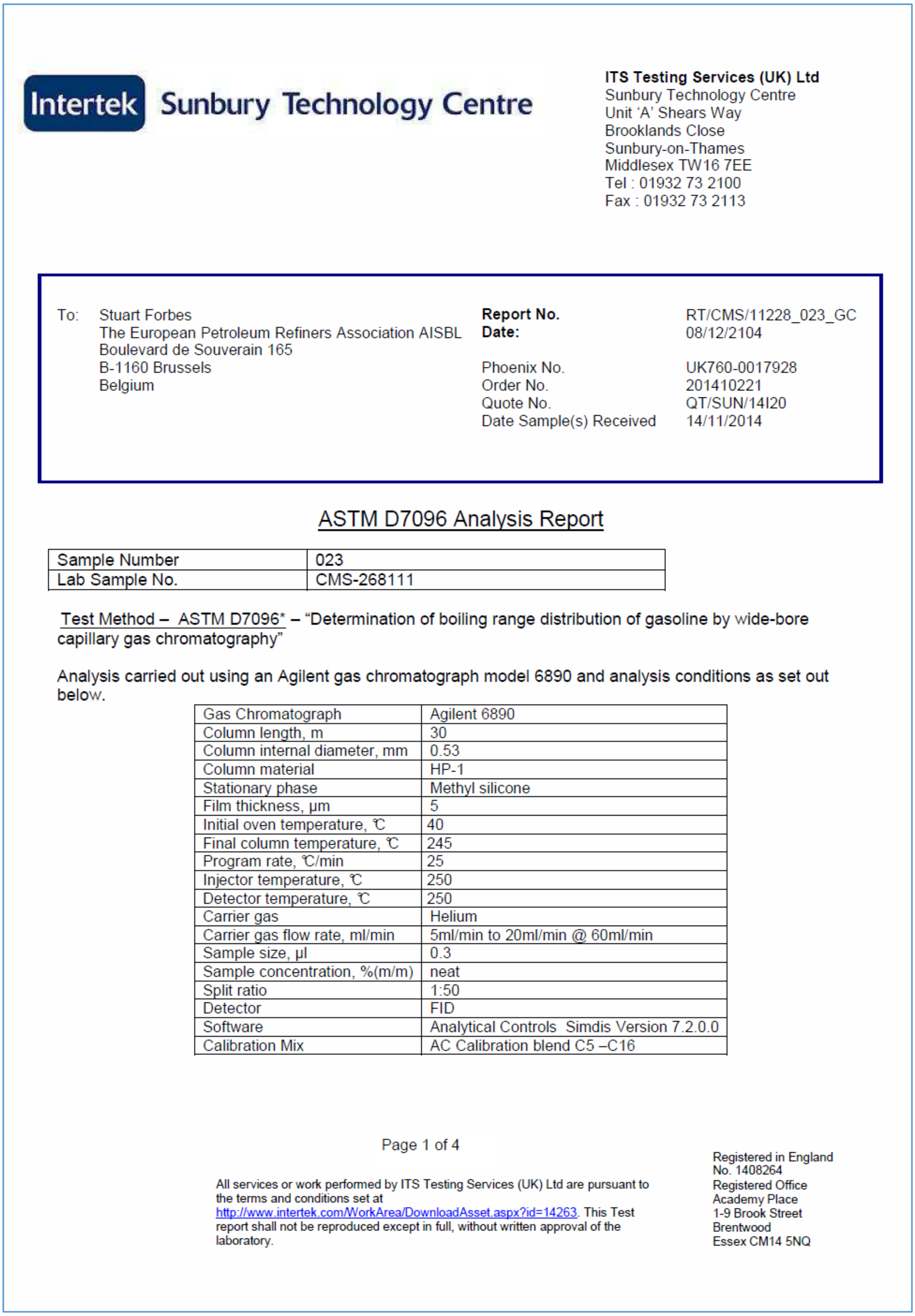
RKing

Reported By:______________________
Rose King
Senior Analyst

Checked By:______________________
Sandra McCullough
Senior technical Specialist

Contact No.: +44(0)1932 732 123

APPENDIX 3 - EXAMPLE OF SIMDIS-GC REPORT (SAMPLE 023 - LBPN)



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The European Petroleum Refiners Association AISBL
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B-1160 Brussels
Belgium

Report No.	RT/CMS/11228_023_GC
Date:	08/12/2104
Phoenix No.	UK760-0017928
Order No.	201410221
Quote No.	QT/SUN/14I20
Date Sample(s) Received	14/11/2014

ASTM D7096 Analysis Report

Sample Number	023
Lab Sample No.	CMS-268111

Test Method – ASTM D7096* – "Determination of boiling range distribution of gasoline by wide-bore capillary gas chromatography"

Analysis carried out using an Agilent gas chromatograph model 6890 and analysis conditions as set out below.

Gas Chromatograph	Agilent 6890
Column length, m	30
Column internal diameter, mm	0.53
Column material	HP-1
Stationary phase	Methyl silicone
Film thickness, µm	5
Initial oven temperature, ℃	40
Final column temperature, ℃	245
Program rate, ℃/min	25
Injector temperature, ℃	250
Detector temperature, ℃	250
Carrier gas	Helium
Carrier gas flow rate, ml/min	5ml/min to 20ml/min @ 60ml/min
Sample size, µl	0.3
Sample concentration, %(m/m)	neat
Split ratio	1:50
Detector	FID
Software	Analytical Controls Simdis Version 7.2.0.0
Calibration Mix	AC Calibration blend C5 –C16

Page 1 of 4

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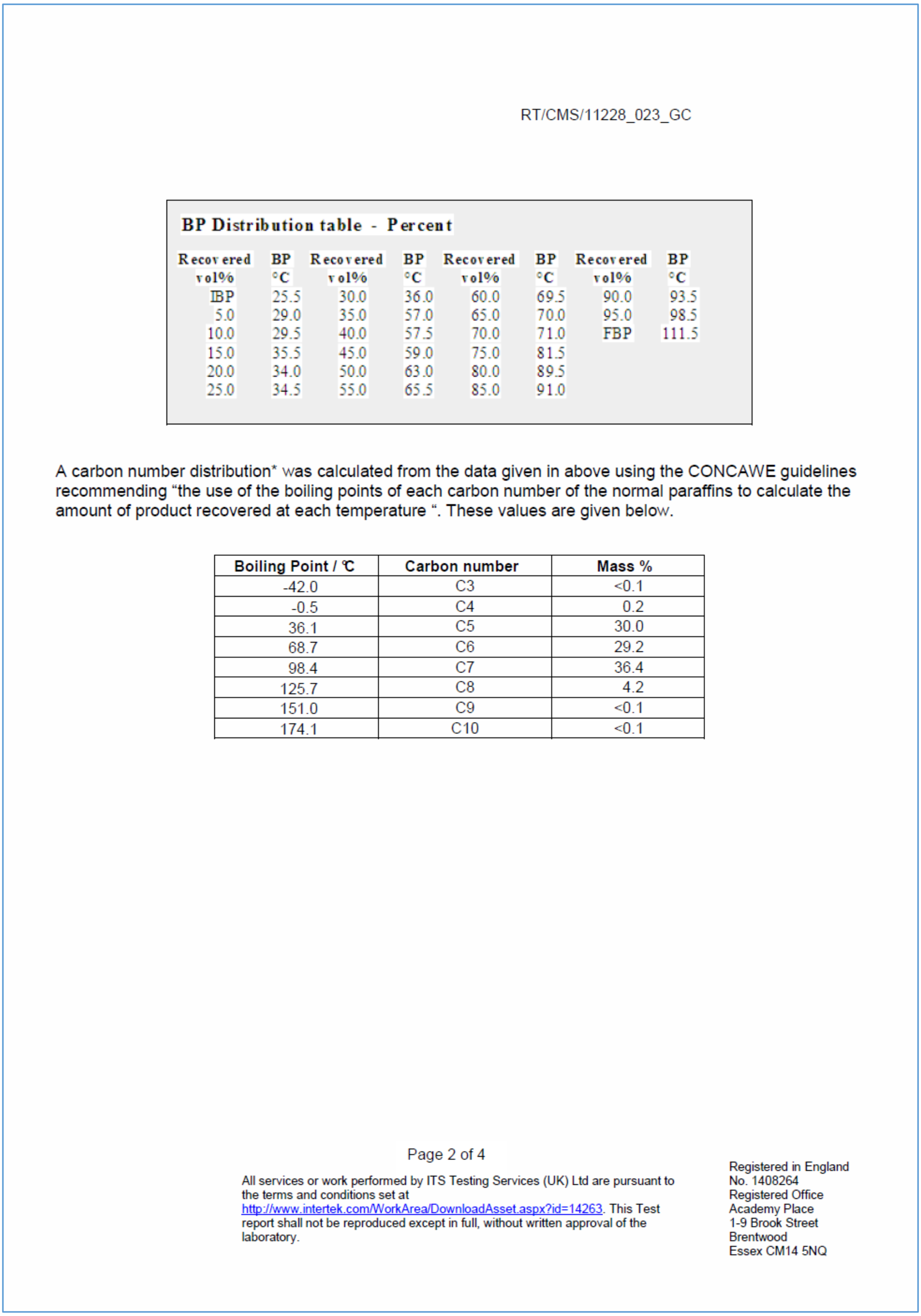

RT/CMS/11228_023_GC

BP Distribution table - Percent

Recovered vol%	BP °C	Recovered vol%	BP °C	Recovered vol%	BP °C	Recovered vol%	BP °C
IBP	25.5	30.0	36.0	60.0	69.5	90.0	93.5
5.0	29.0	35.0	57.0	65.0	70.0	95.0	98.5
10.0	29.5	40.0	57.5	70.0	71.0	FBP	111.5
15.0	35.5	45.0	59.0	75.0	81.5		
20.0	34.0	50.0	63.0	80.0	89.5		
25.0	34.5	55.0	65.5	85.0	91.0		

A carbon number distribution* was calculated from the data given in above using the CONCAWE guidelines recommending "the use of the boiling points of each carbon number of the normal paraffins to calculate the amount of product recovered at each temperature ". These values are given below.

Boiling Point / ℃	Carbon number	Mass %
-42.0	C3	<0.1
-0.5	C4	0.2
36.1	C5	30.0
68.7	C6	29.2
98.4	C7	36.4
125.7	C8	4.2
151.0	C9	<0.1
174.1	C10	<0.1

Page 2 of 4

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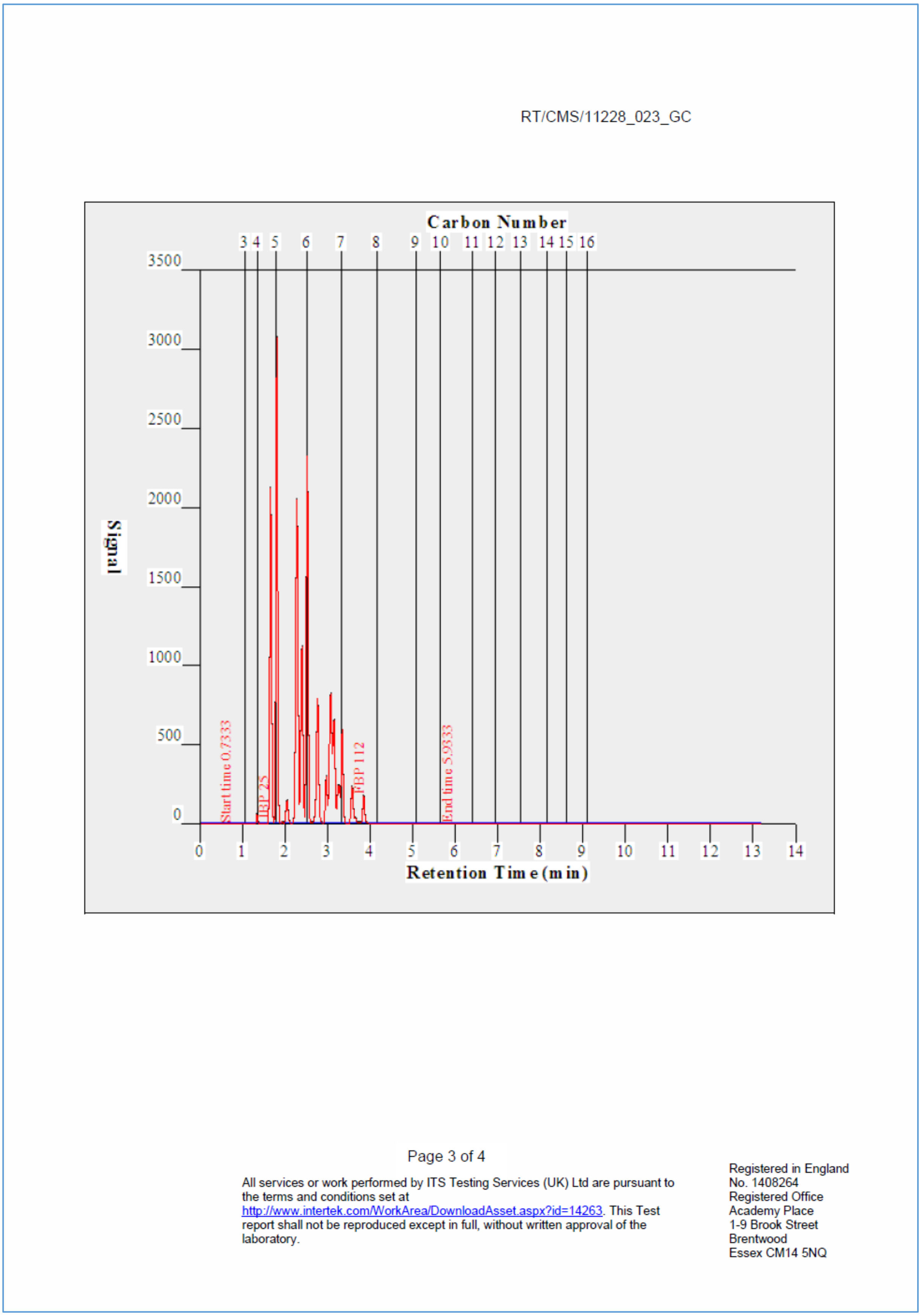
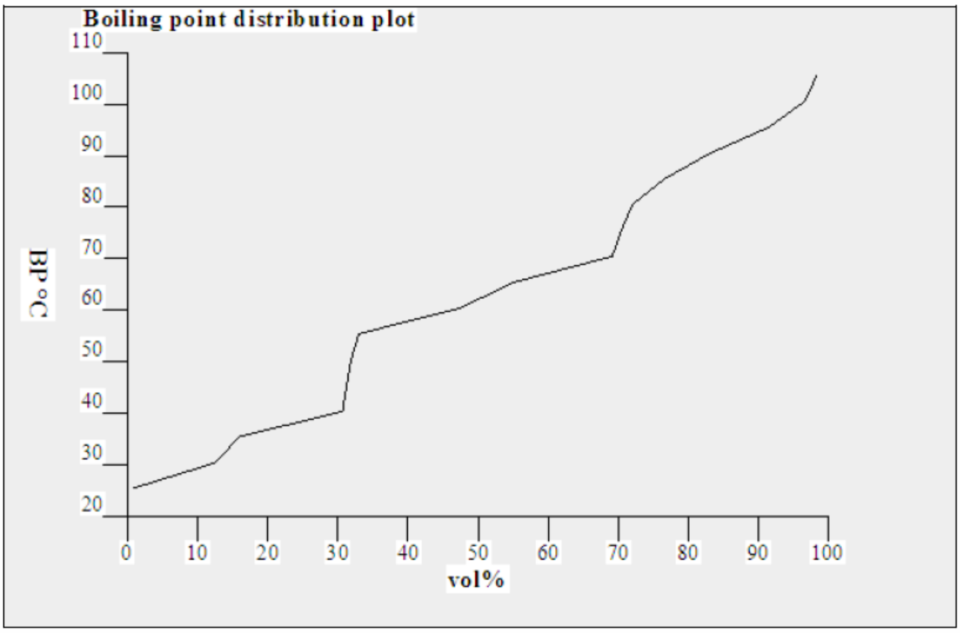


RT/CMS/11228_023_GC

RT/CMS/11228_023_GC



* Test not UKAS accredited

Analysis has been carried out on a sub-sample of the sample as received, independent of sampling procedure, using the latest versions of all test methods.

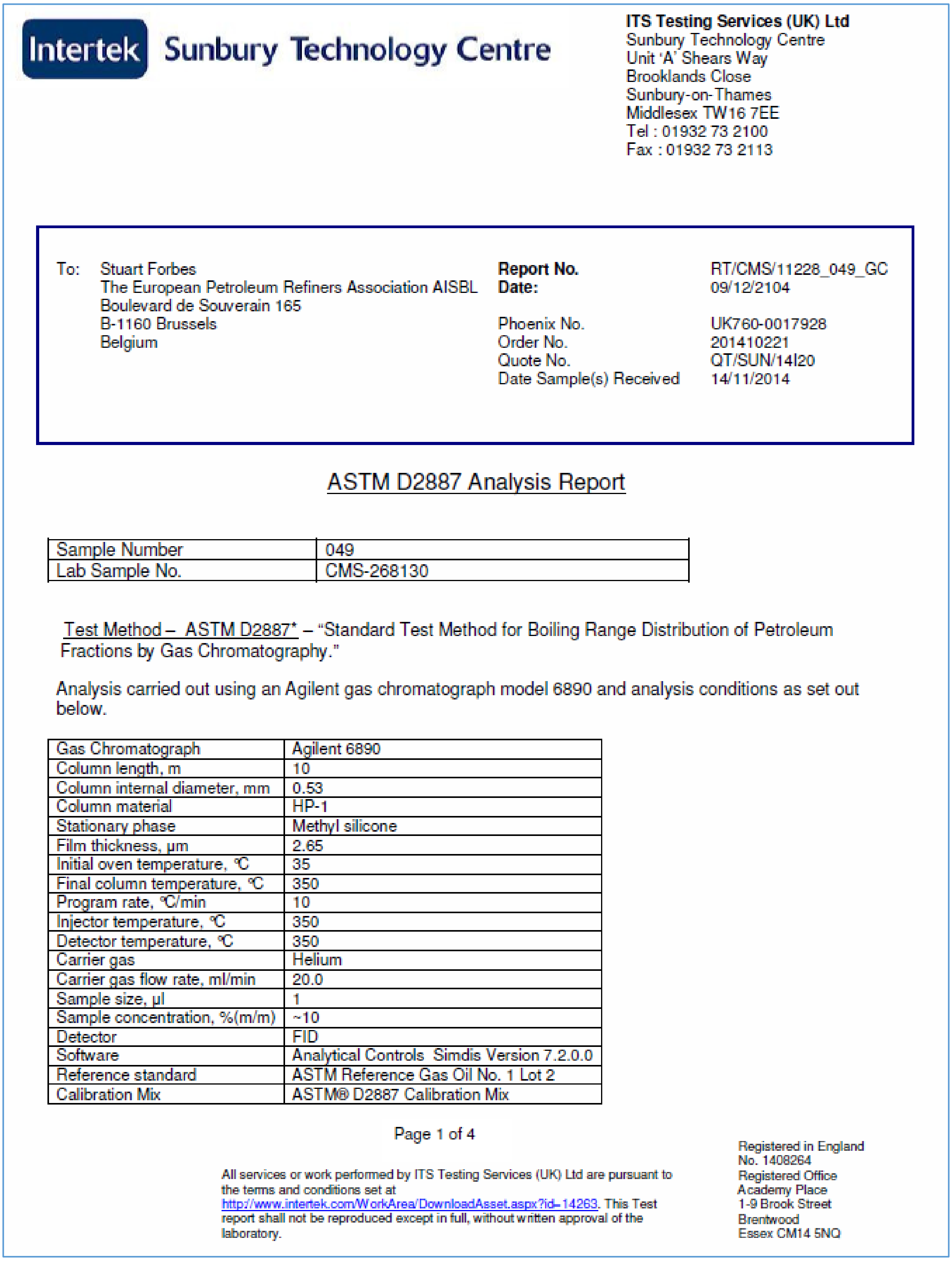
Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

Reported By:
Sandra McCullough
Senior Technical Specialist

Checked By:
Kirsty Clark
Technical Specialist

Contact No.: +44(0)1932 732 123

APPENDIX 4 - EXAMPLE OF SIMDIS-GC REPORT (SAMPLE 049 - KEROSINE)



Intertek Sunbury Technology Centre

ITS Testing Services (UK) Ltd
Sunbury Technology Centre
Unit ‘A’ Shears Way
Brooklands Close
Sunbury-on-Thames
Middlesex TW16 7EE
Tel : 01932 73 2100
Fax : 01932 73 2113

To: Stuart Forbes
The European Petroleum Refiners Association AISBL
Boulevard de Souverain 165
B-1160 Brussels
Belgium

Report No.	RT/CMS/11228_049_GC
Date:	09/12/2104
Phoenix No.	UK760-0017928
Order No.	201410221
Quote No.	QT/SUN/14I20
Date Sample(s) Received	14/11/2014

ASTM D2887 Analysis Report

Sample Number	049
Lab Sample No.	CMS-268130

Test Method – ASTM D2887* – “Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography.”

Analysis carried out using an Agilent gas chromatograph model 6890 and analysis conditions as set out below.

Gas Chromatograph	Agilent 6890
Column length, m	10
Column internal diameter, mm	0.53
Column material	HP-1
Stationary phase	Methyl silicone
Film thickness, µm	2.65
Initial oven temperature, °C	35
Final column temperature, °C	350
Program rate, °C/min	10
Injector temperature, °C	350
Detector temperature, °C	350
Carrier gas	Helium
Carrier gas flow rate, ml/min	20.0
Sample size, µl	1
Sample concentration, %(m/m)	~10
Detector	FID
Software	Analytical Controls Simdis Version 7.2.0.0
Reference standard	ASTM Reference Gas Oil No. 1 Lot 2
Calibration Mix	ASTM® D2887 Calibration Mix

Page 1 of 4

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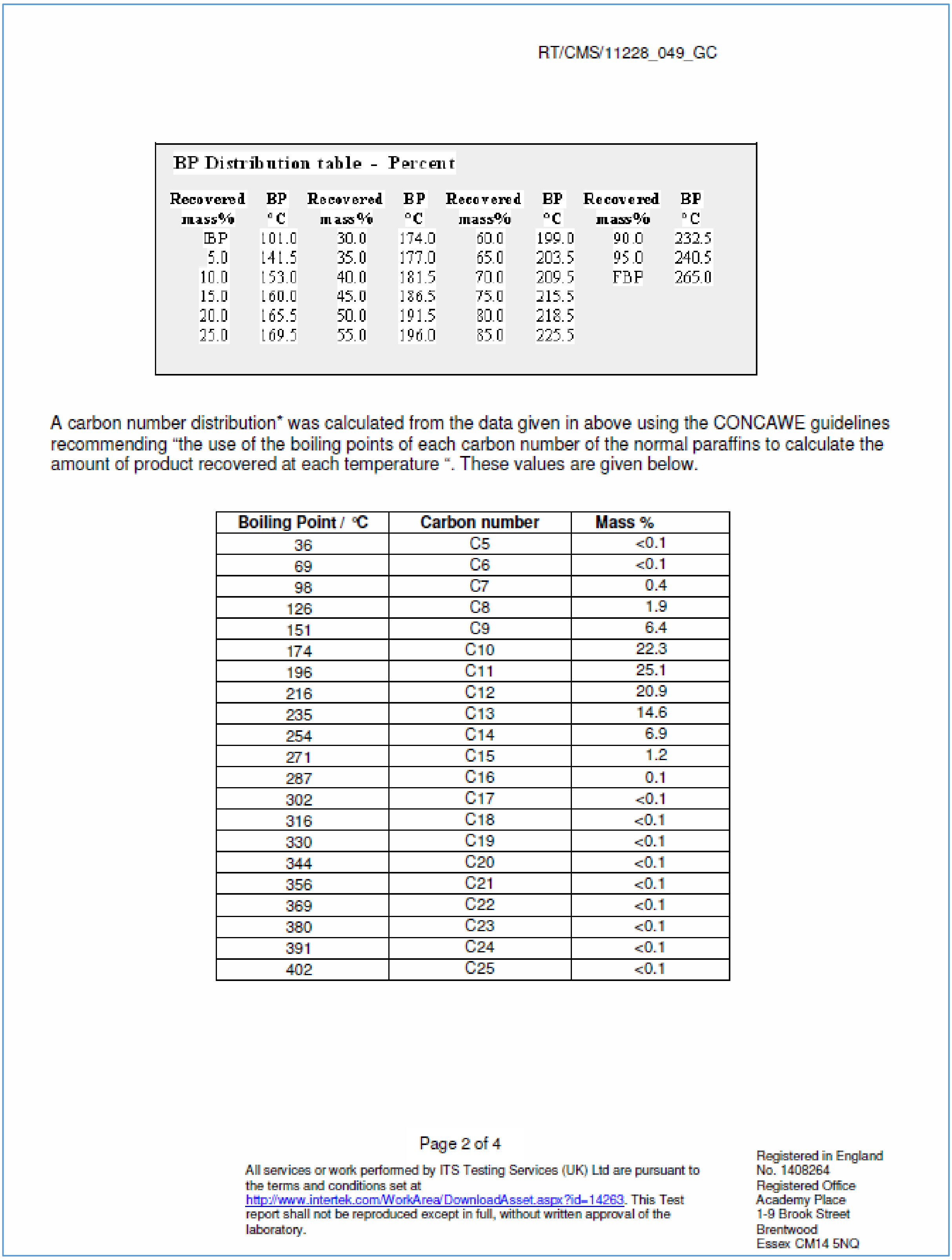

RT/CMS/11228_049_GC

BP Distribution table - Percent

Recovered mass%	BP °C	Recovered mass%	BP °C	Recovered mass%	BP °C	Recovered mass%	BP °C
IBP	101.0	30.0	174.0	60.0	199.0	90.0	232.5
5.0	141.5	35.0	177.0	65.0	203.5	95.0	240.5
10.0	153.0	40.0	181.5	70.0	209.5	FBP	265.0
15.0	160.0	45.0	186.5	75.0	215.5		
20.0	165.5	50.0	191.5	80.0	218.5		
25.0	169.5	55.0	196.0	85.0	225.5		

A carbon number distribution* was calculated from the data given in above using the CONCAWE guidelines recommending "the use of the boiling points of each carbon number of the normal paraffins to calculate the amount of product recovered at each temperature ". These values are given below.

Boiling Point / °C	Carbon number	Mass %
36	C5	<0.1
69	C6	<0.1
98	C7	0.4
126	C8	1.9
151	C9	6.4
174	C10	22.3
196	C11	25.1
216	C12	20.9
235	C13	14.6
254	C14	6.9
271	C15	1.2
287	C16	0.1
302	C17	<0.1
316	C18	<0.1
330	C19	<0.1
344	C20	<0.1
356	C21	<0.1
369	C22	<0.1
380	C23	<0.1
391	C24	<0.1
402	C25	<0.1

Page 2 of 4

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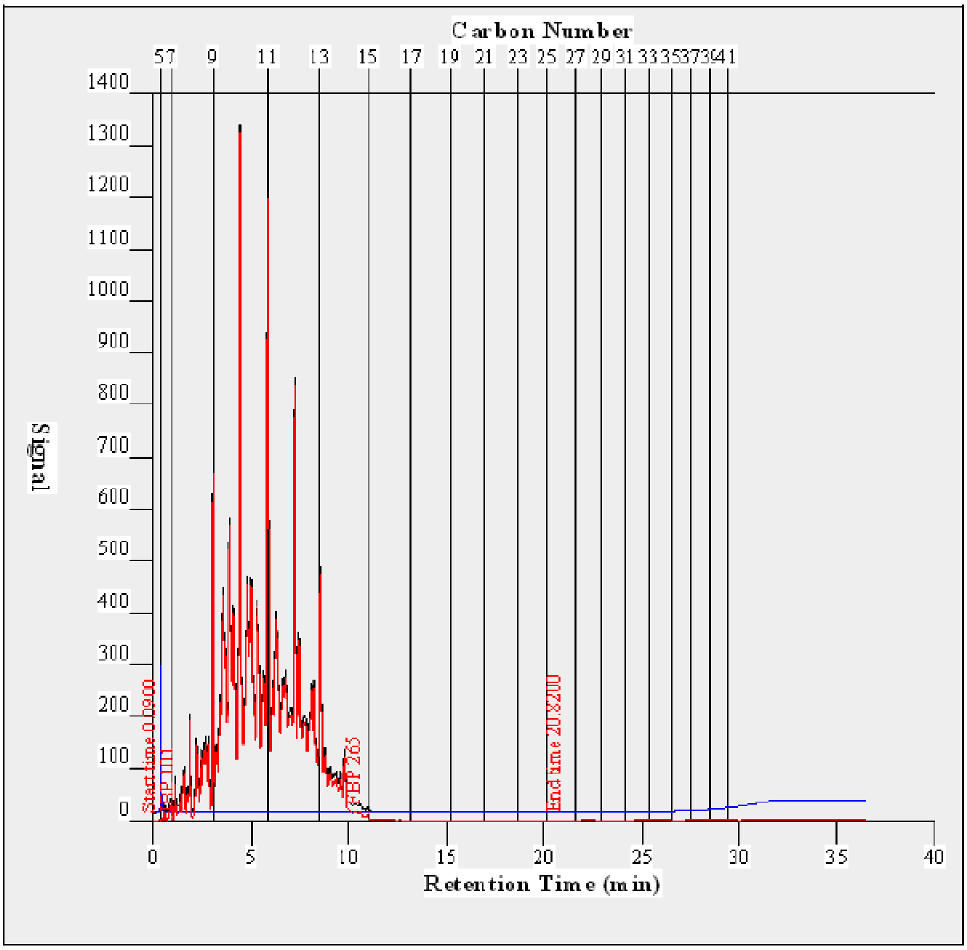
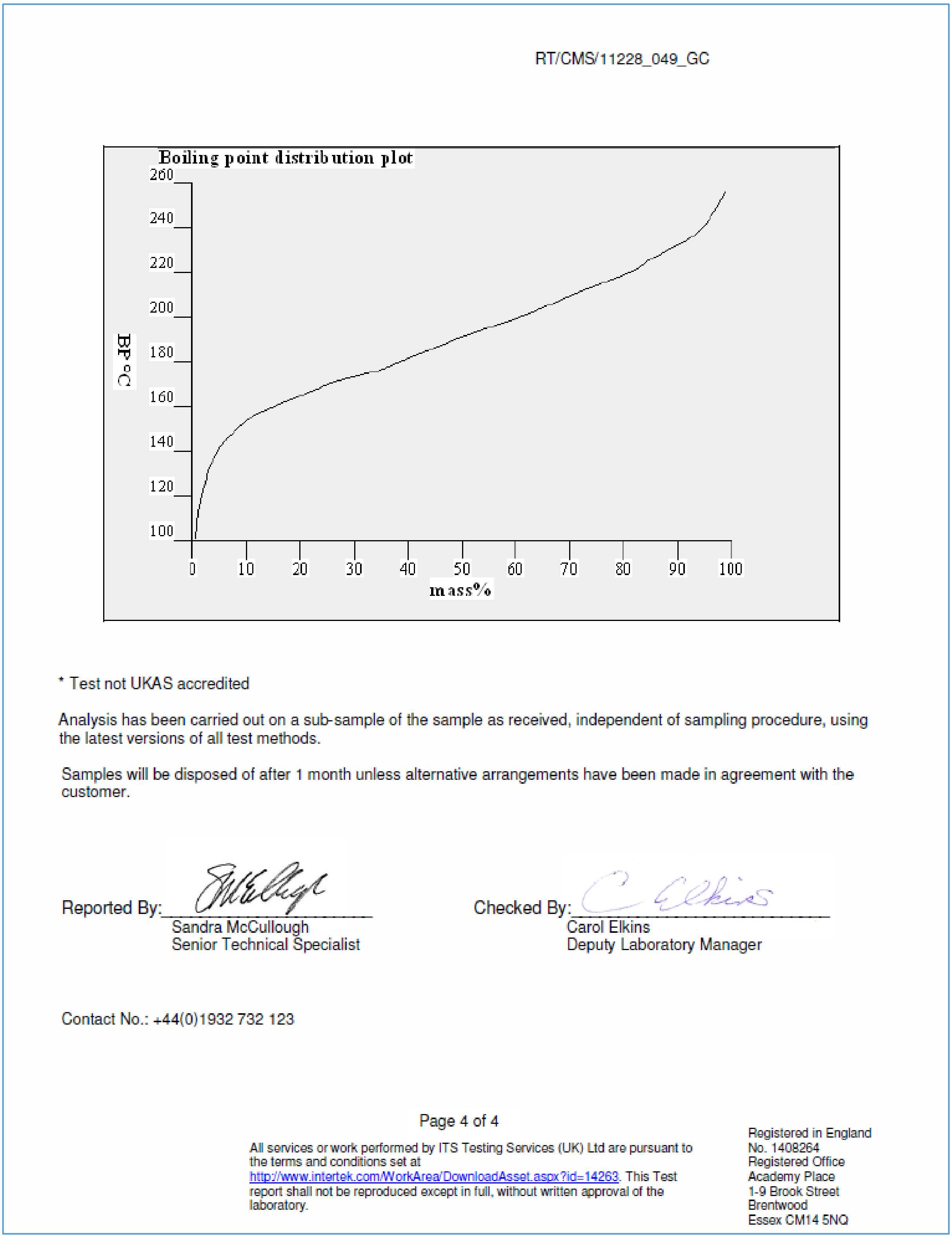
RT/CMS/11228_049_GC





RT/CMS/11228_049_GC

* Test not UKAS accredited

Analysis has been carried out on a sub-sample of the sample as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

Reported By:______________________
Sandra McCullough
Senior Technical Specialist

Checked By: C Elkins
Carol Elkins
Deputy Laboratory Manager

Contact No.: +44(0)1932 732 123

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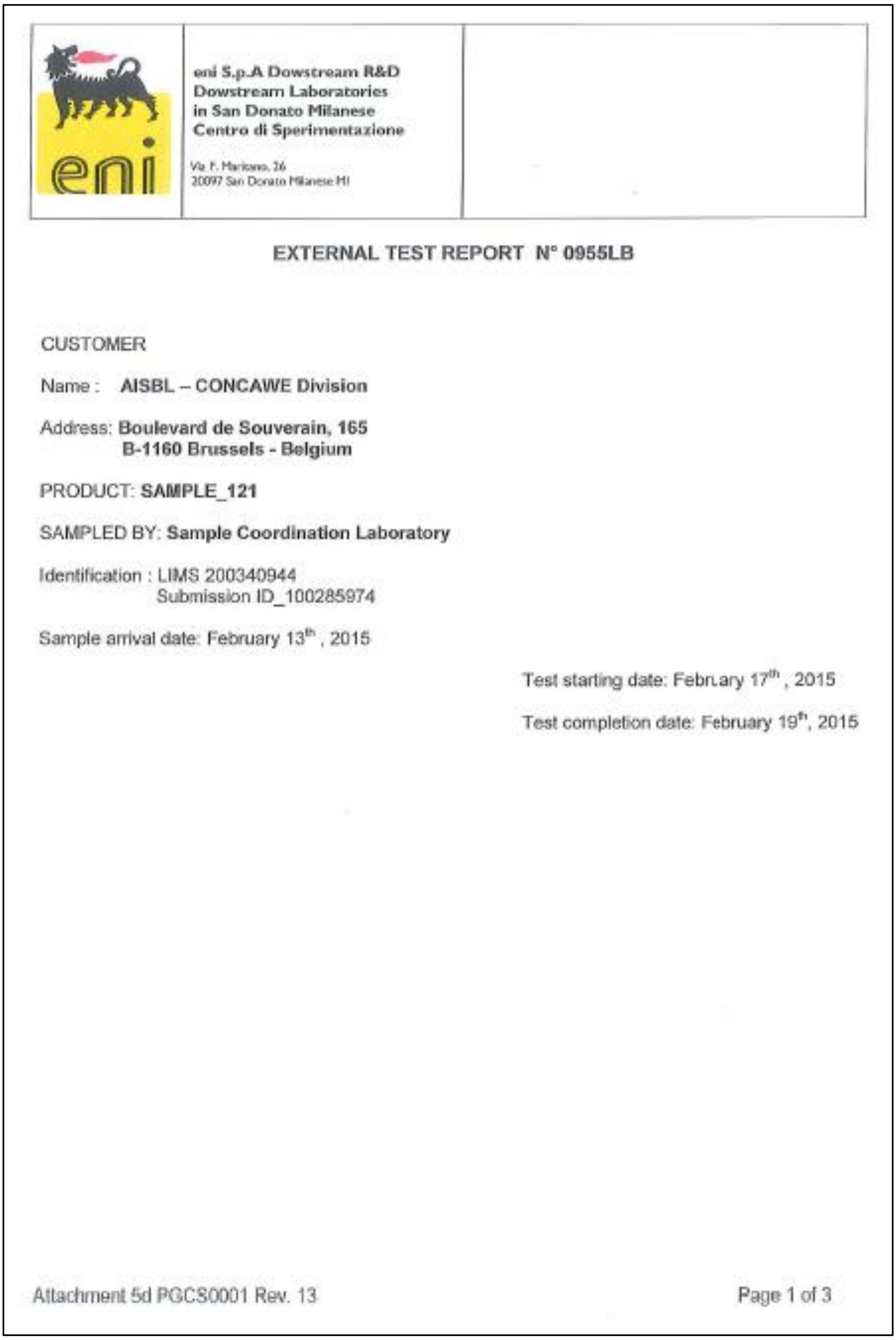
APPENDIX 5 - EXAMPLE OF SIMDIS-GC REPORT (SAMPLE 121 - CGO)



eni S.p.A Dowstream R&D
Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

Via F. Maritano, 26
20097 San Donato Milanese MI

EXTERNAL TEST REPORT N° 0955LB

CUSTOMER

Name : **AISBL – CONCAWE Division**

Address: **Boulevard de Souverain, 165**
B-1160 Brussels - Belgium

PRODUCT: **SAMPLE_121**

SAMPLED BY: **Sample Coordination Laboratory**

Identification : LIMS 200340944
Submission ID_100285974

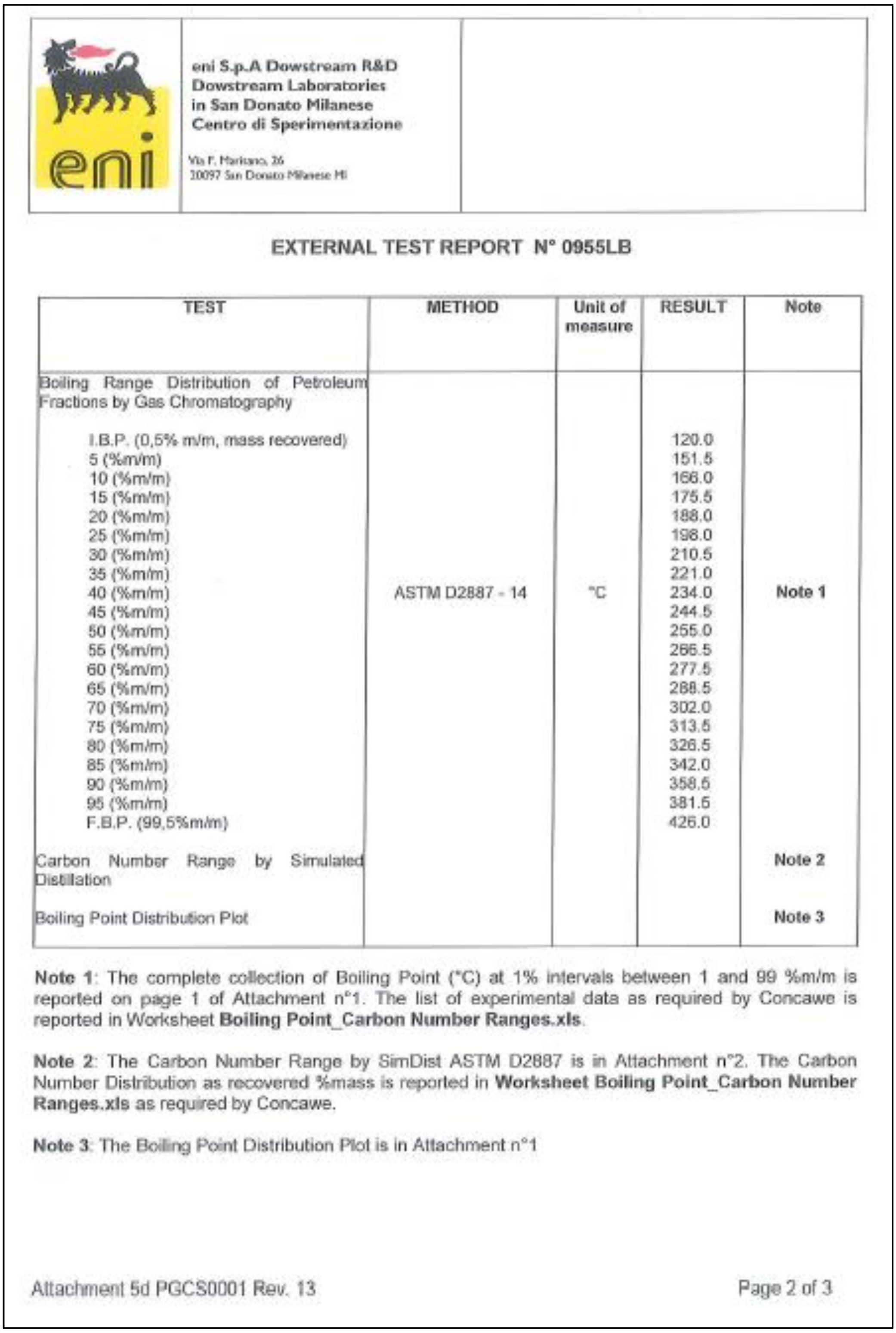
Sample arrival date: February 13th , 2015

Test starting date: February 17th , 2015

Test completion date: February 19th, 2015

Attachment 5d PGCS0001 Rev. 13

Page 1 of 3



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EXTERNAL TEST REPORT N° 0955LB

TEST	METHOD	Unit of measure	RESULT	Note
Boiling Range Distribution of Petroleum Fractions by Gas Chromatography	ASTM D2887 - 14	°C		Note 1
I.B.P. (0,5% m/m, mass recovered)			120.0	
5 (%m/m)			151.5	
10 (%m/m)			166.0	
15 (%m/m)			175.5	
20 (%m/m)			188.0	
25 (%m/m)			198.0	
30 (%m/m)			210.5	
35 (%m/m)			221.0	
40 (%m/m)			234.0	
45 (%m/m)			244.5	
50 (%m/m)			255.0	
55 (%m/m)			266.5	
60 (%m/m)			277.5	
65 (%m/m)			288.5	
70 (%m/m)			302.0	
75 (%m/m)			313.5	
80 (%m/m)			326.5	
85 (%m/m)			342.0	
90 (%m/m)			358.5	
95 (%m/m)			381.5	
F.B.P. (99,5%m/m)			426.0	
Carbon Number Range by Simulated Distillation				Note 2
Boiling Point Distribution Plot				Note 3

Note 1: The complete collection of Boiling Point (°C) at 1% intervals between 1 and 99 %m/m is reported on page 1 of Attachment n°1. The list of experimental data as required by Concawe is reported in Worksheet **Boiling Point_Carbon Number Ranges.xls**.

Note 2: The Carbon Number Range by SimDist ASTM D2887 is in Attachment n°2. The Carbon Number Distribution as recovered %mass is reported in **Worksheet Boiling Point_Carbon Number Ranges.xls** as required by Concawe.

Note 3: The Boiling Point Distribution Plot is in Attachment n°1

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EXTERNAL TEST REPORT N° 0955LB

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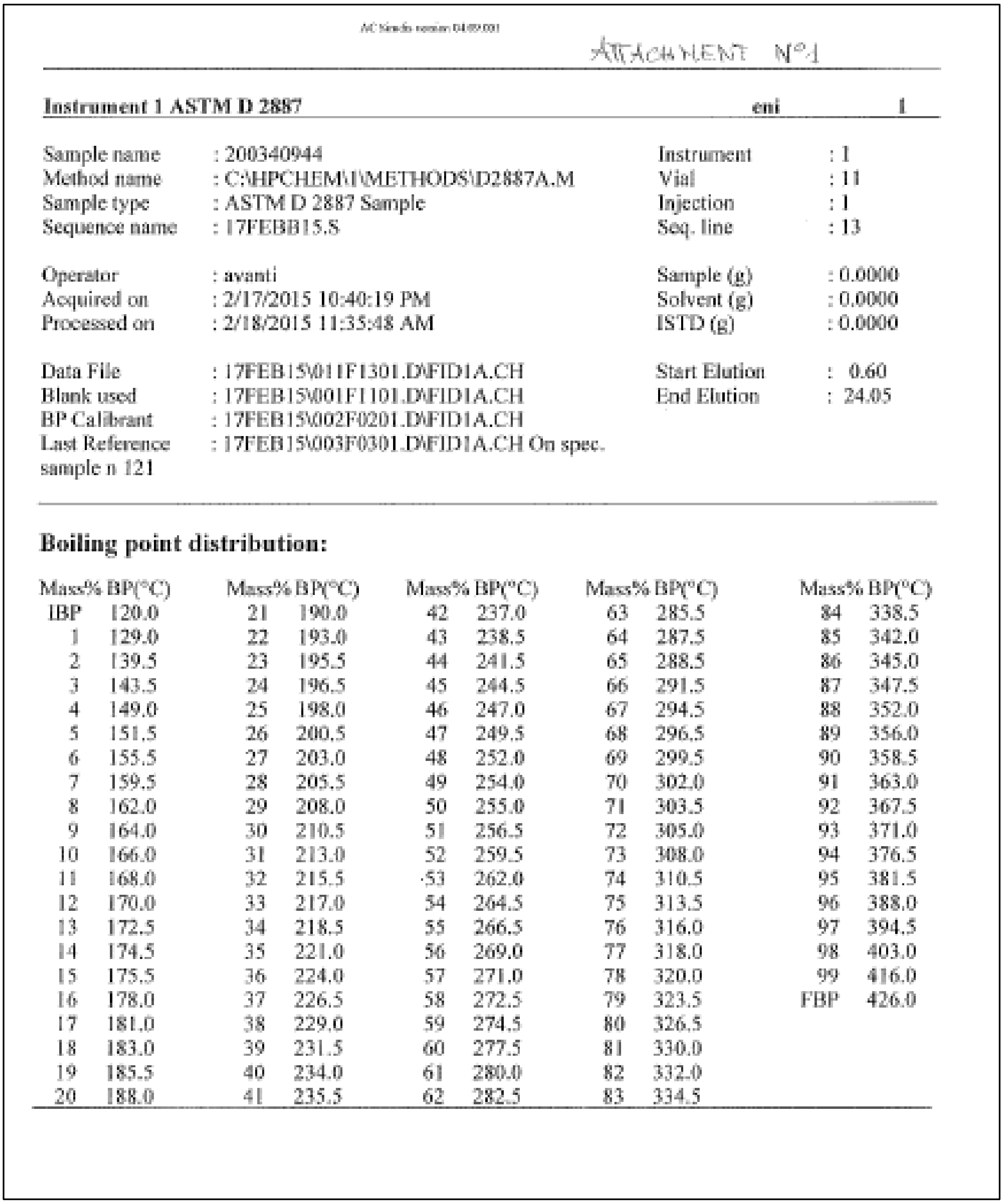
Issue date: March 4th, 2015

SUPERVISOR	MANAGING DIRECTOR
Patrizia Ruggieri	Paolo Pollesel

Attachment 5d PGCS0001 Rev. 13

Page 3 of 3



AC Simdis version 04.09.001

ATTACHMENT N°1

Instrument 1 ASTM D 2887 **eni** **1**

Sample name : 200340944
Method name : C:\HPCHEM\1\METHODS\D2887A.M
Sample type : ASTM D 2887 Sample
Sequence name : 17FEBB15.S

Instrument : 1
Vial : 11
Injection : 1
Seq. line : 13

Operator : avanti
Acquired on : 2/17/2015 10:40:19 PM
Processed on : 2/18/2015 11:35:48 AM

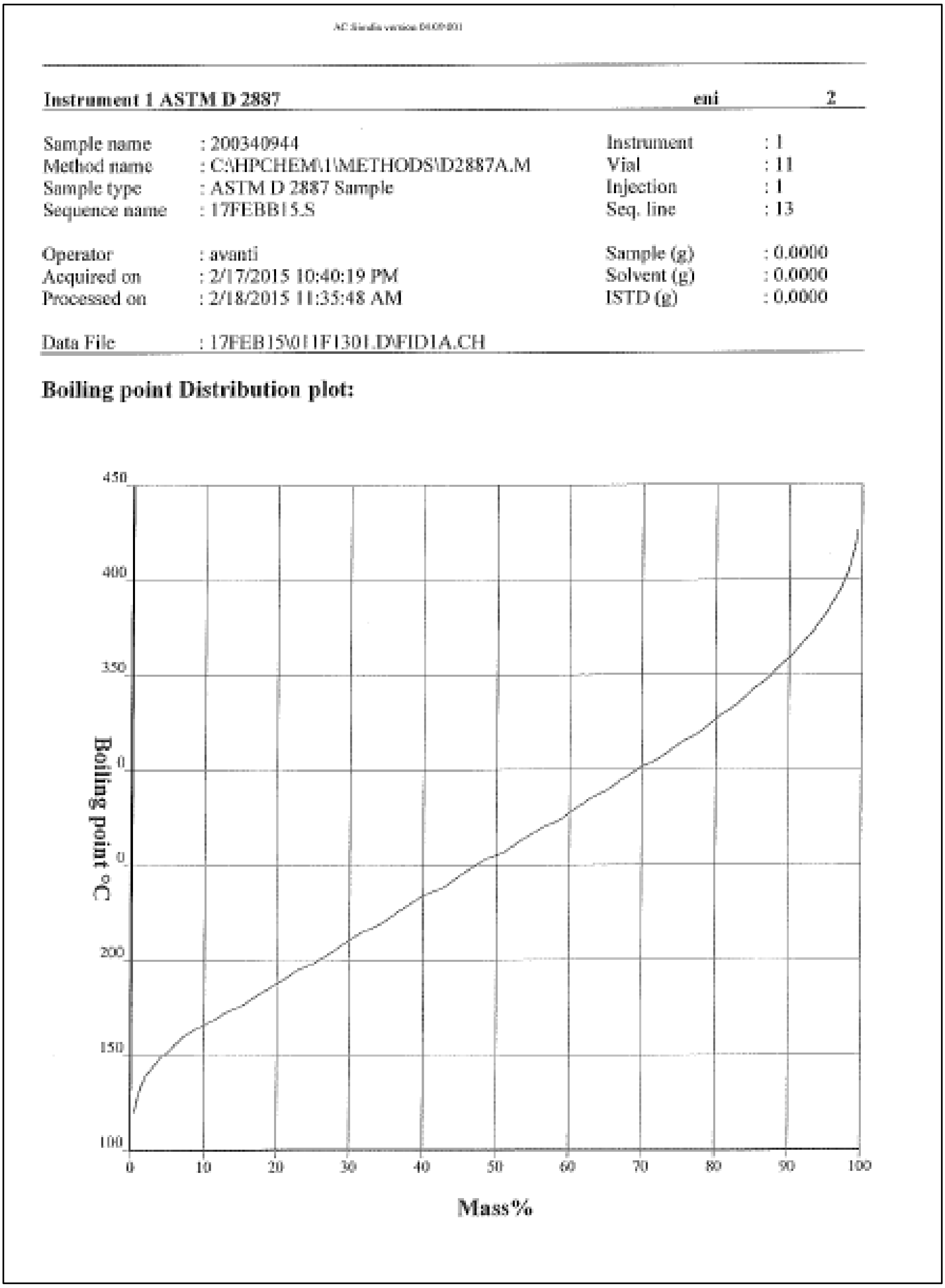
Sample (g) : 0.0000
Solvent (g) : 0.0000
ISTD (g) : 0.0000

Data File : 17FEB15\011F1301.D\FID1A.CH
Blank used : 17FEB15\001F1101.D\FID1A.CH
BP Calibrant : 17FEB15\002F0201.D\FID1A.CH
Last Reference : 17FEB15\003F0301.D\FID1A.CH On spec.
sample n 121

Start Elution : 0.60
End Elution : 24.05

Boiling point distribution:

Mass%	BP(°C)	Mass%	BP(°C)	Mass%	BP(°C)	Mass%	BP(°C)	Mass%	BP(°C)
IBP	120.0	21	190.0	42	237.0	63	285.5	84	338.5
1	129.0	22	193.0	43	238.5	64	287.5	85	342.0
2	139.5	23	195.5	44	241.5	65	288.5	86	345.0
3	143.5	24	196.5	45	244.5	66	291.5	87	347.5
4	149.0	25	198.0	46	247.0	67	294.5	88	352.0
5	151.5	26	200.5	47	249.5	68	296.5	89	356.0
6	155.5	27	203.0	48	252.0	69	299.5	90	358.5
7	159.5	28	205.5	49	254.0	70	302.0	91	363.0
8	162.0	29	208.0	50	255.0	71	303.5	92	367.5
9	164.0	30	210.5	51	256.5	72	305.0	93	371.0
10	166.0	31	213.0	52	259.5	73	308.0	94	376.5
11	168.0	32	215.5	53	262.0	74	310.5	95	381.5
12	170.0	33	217.0	54	264.5	75	313.5	96	388.0
13	172.5	34	218.5	55	266.5	76	316.0	97	394.5
14	174.5	35	221.0	56	269.0	77	318.0	98	403.0
15	175.5	36	224.0	57	271.0	78	320.0	99	416.0
16	178.0	37	226.5	58	272.5	79	323.5	FBP	426.0
17	181.0	38	229.0	59	274.5	80	326.5		
18	183.0	39	231.5	60	277.5	81	330.0		
19	185.5	40	234.0	61	280.0	82	332.0		
20	188.0	41	235.5	62	282.5	83	334.5		



Instrument 1 ASTM D 2887 eni 2

Sample name : 200340944
Method name : C:\HPCHEM\1\METHODS\D2887A.M
Sample type : ASTM D 2887 Sample
Sequence name : 17FEBB15.S

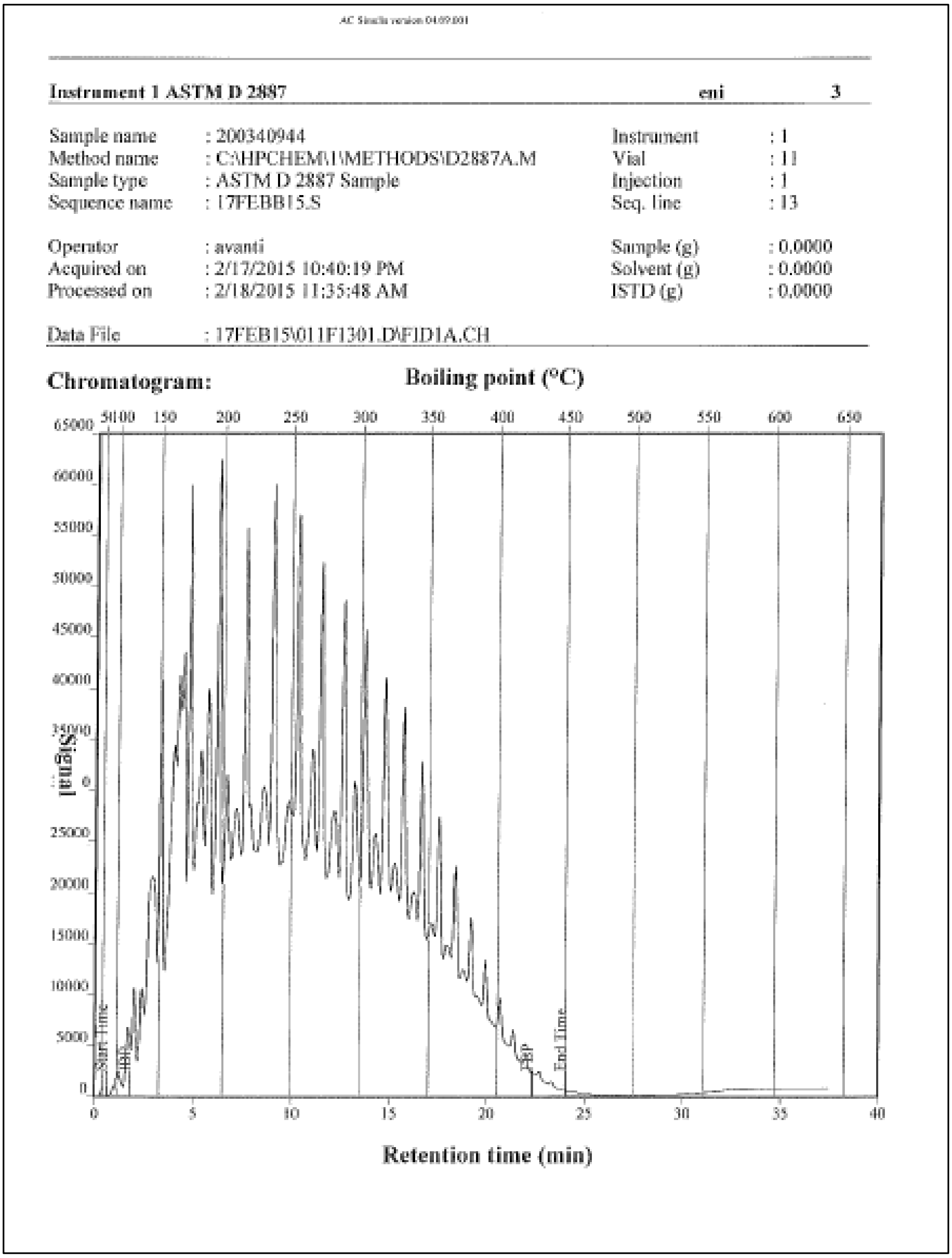
Instrument : 1
Vial : 11
Injection : 1
Seq. line : 13

Operator : avanti
Acquired on : 2/17/2015 10:40:19 PM
Processed on : 2/18/2015 11:35:48 AM

Sample (g) : 0.0000
Solvent (g) : 0.0000
ISTD (g) : 0.0000

Data File : 17FEB15\011F1301.D\FID1A.CH

Boiling point Distribution plot:



AC Simdis version 04.09.001

Instrument 1 ASTM D 2887 **eni** **3**

Sample name : 200340944
Method name : C:\HPCHEM\1\METHODS\D2887A.M
Sample type : ASTM D 2887 Sample
Sequence name : 17FEBB15.S

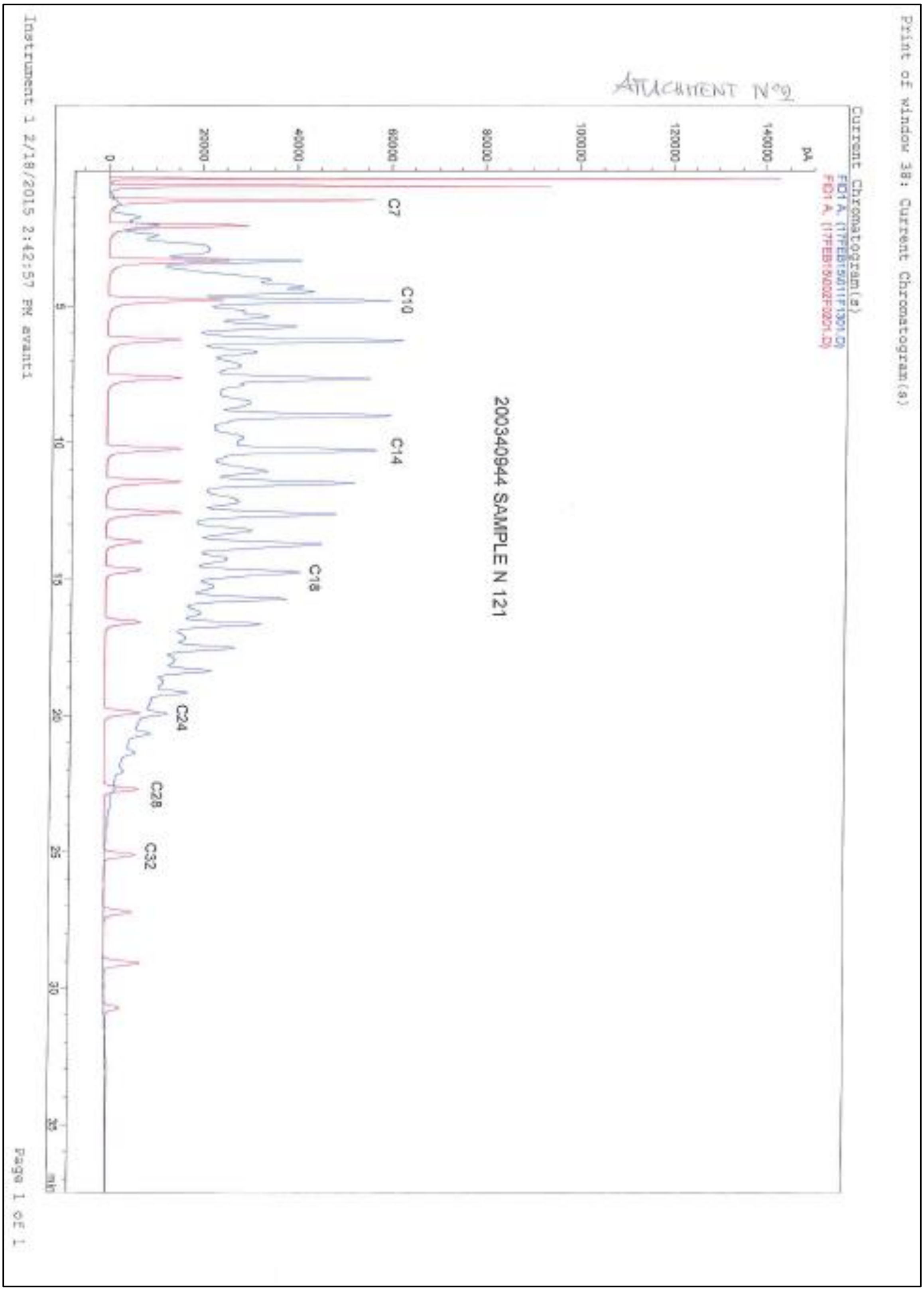
Instrument : 1
Vial : 11
Injection : 1
Seq. line : 13

Operator : avanti
Acquired on : 2/17/2015 10:40:19 PM
Processed on : 2/18/2015 11:35:48 AM

Sample (g) : 0.0000
Solvent (g) : 0.0000
ISTD (g) : 0.0000

Data File : 17FEB15\011F1301.D\FID1A.CH

Chromatogram:



Print of window 38: Current Chromatogram(s)

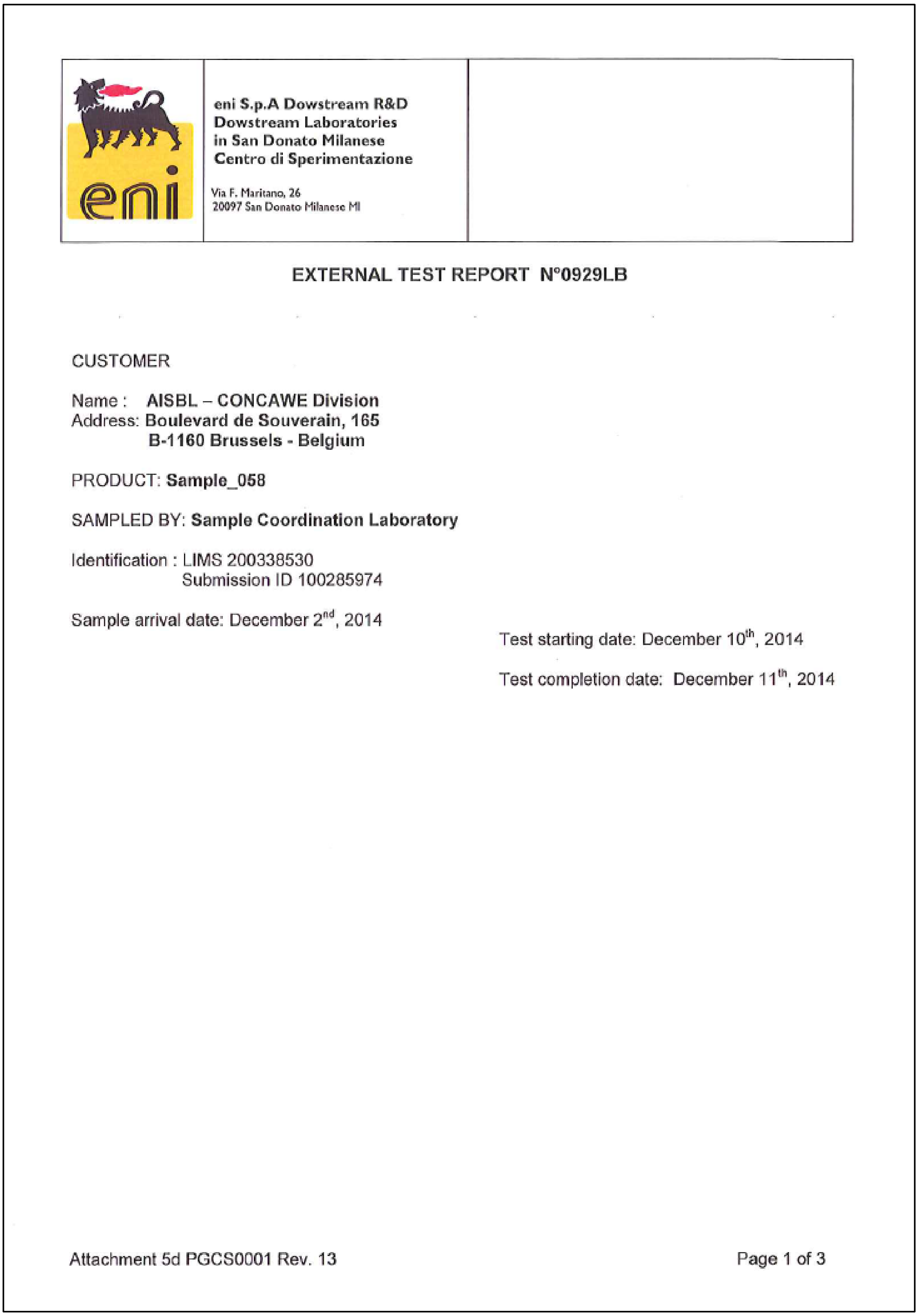
ATTACHMENT N°2

200340944 SAMPLE N 121

Instrument 1 2/18/2015 2:42:57 PM avanti

Page 1 of 1

APPENDIX 6 – EXAMPLE OF SIMDIS-GC REPORT (SAMPLE 058 - HFO)



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Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

Via F. Maritano, 26
20097 San Donato Milanese MI

EXTERNAL TEST REPORT **N°0929LB**

CUSTOMER

Name : **AISBL – CONCAWE Division**
Address: **Boulevard de Souverain, 165**
B-1160 Brussels - Belgium

PRODUCT: **Sample_058**

SAMPLED BY: **Sample Coordination Laboratory**

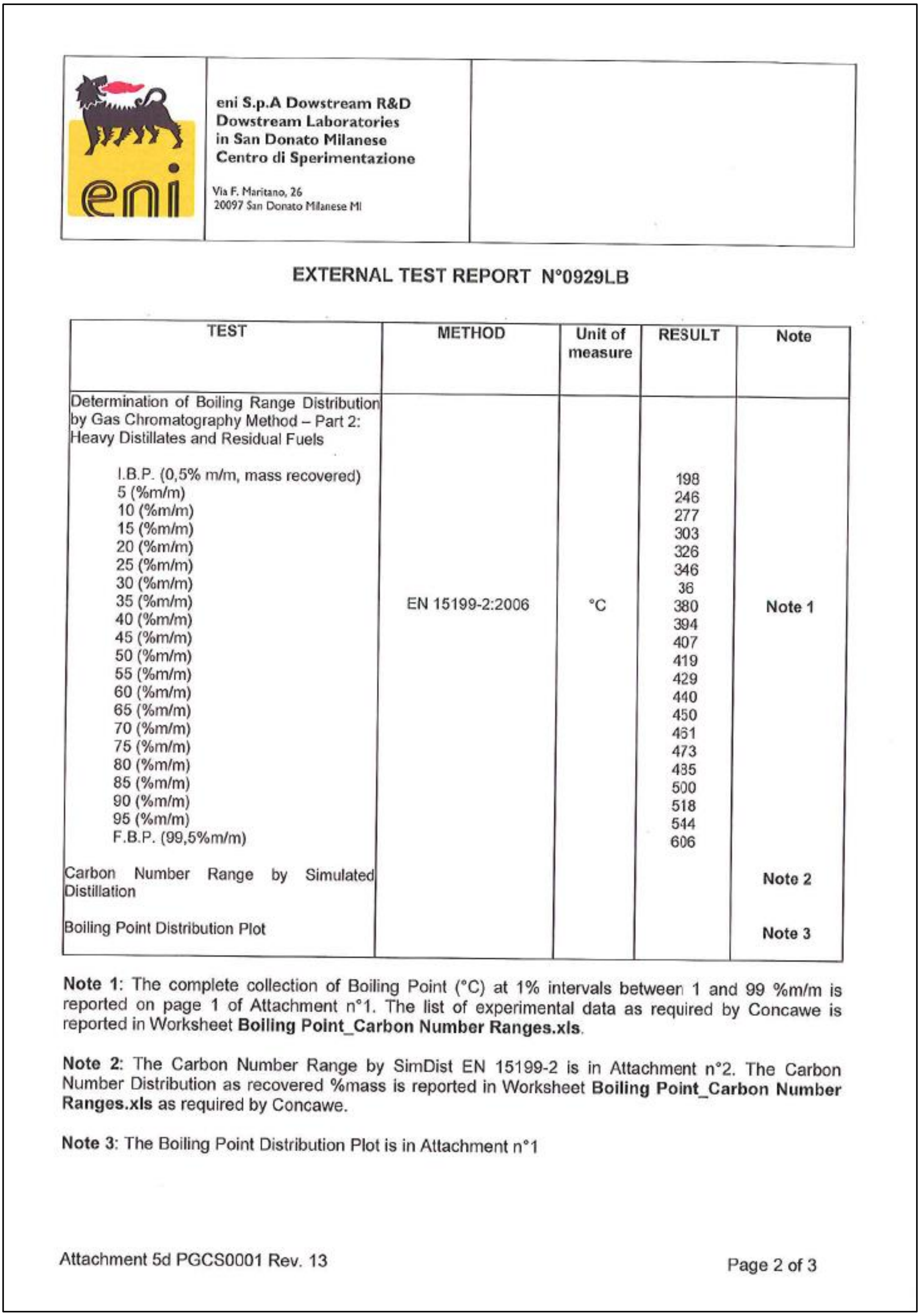
Identification : LIMS 200338530
Submission ID 100285974

Sample arrival date: December 2nd, 2014

Test starting date: December 10th, 2014

Test completion date: December 11th, 2014

Attachment 5d PGCS0001 Rev. 13 Page 1 of 3



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in San Donato Milanese
Centro di Sperimentazione

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EXTERNAL TEST REPORT N°0929LB

TEST	METHOD	Unit of measure	RESULT	Note
Determination of Boiling Range Distribution by Gas Chromatography Method – Part 2: Heavy Distillates and Residual Fuels	EN 15199-2:2006	°C		Note 1
I.B.P. (0,5% m/m, mass recovered)			198	
5 (%m/m)			246	
10 (%m/m)			277	
15 (%m/m)			303	
20 (%m/m)			326	
25 (%m/m)			346	
30 (%m/m)			36	
35 (%m/m)			380	
40 (%m/m)			394	
45 (%m/m)			407	
50 (%m/m)			419	
55 (%m/m)			429	
60 (%m/m)			440	
65 (%m/m)			450	
70 (%m/m)			461	
75 (%m/m)			473	
80 (%m/m)			485	
85 (%m/m)			500	
90 (%m/m)			518	
95 (%m/m)			544	
F.B.P. (99,5%m/m)			606	
Carbon Number Range by Simulated Distillation				Note 2
Boiling Point Distribution Plot				Note 3

Note 1: The complete collection of Boiling Point (°C) at 1% intervals between 1 and 99 %m/m is reported on page 1 of Attachment n°1. The list of experimental data as required by Concawe is reported in Worksheet **Boiling Point_Carbon Number Ranges.xls**.

Note 2: The Carbon Number Range by SimDist EN 15199-2 is in Attachment n°2. The Carbon Number Distribution as recovered %mass is reported in Worksheet **Boiling Point_Carbon Number Ranges.xls** as required by Concawe.

Note 3: The Boiling Point Distribution Plot is in Attachment n°1

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Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

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20097 San Donato Milanese MI

EXTERNAL TEST REPORT N°0929LB

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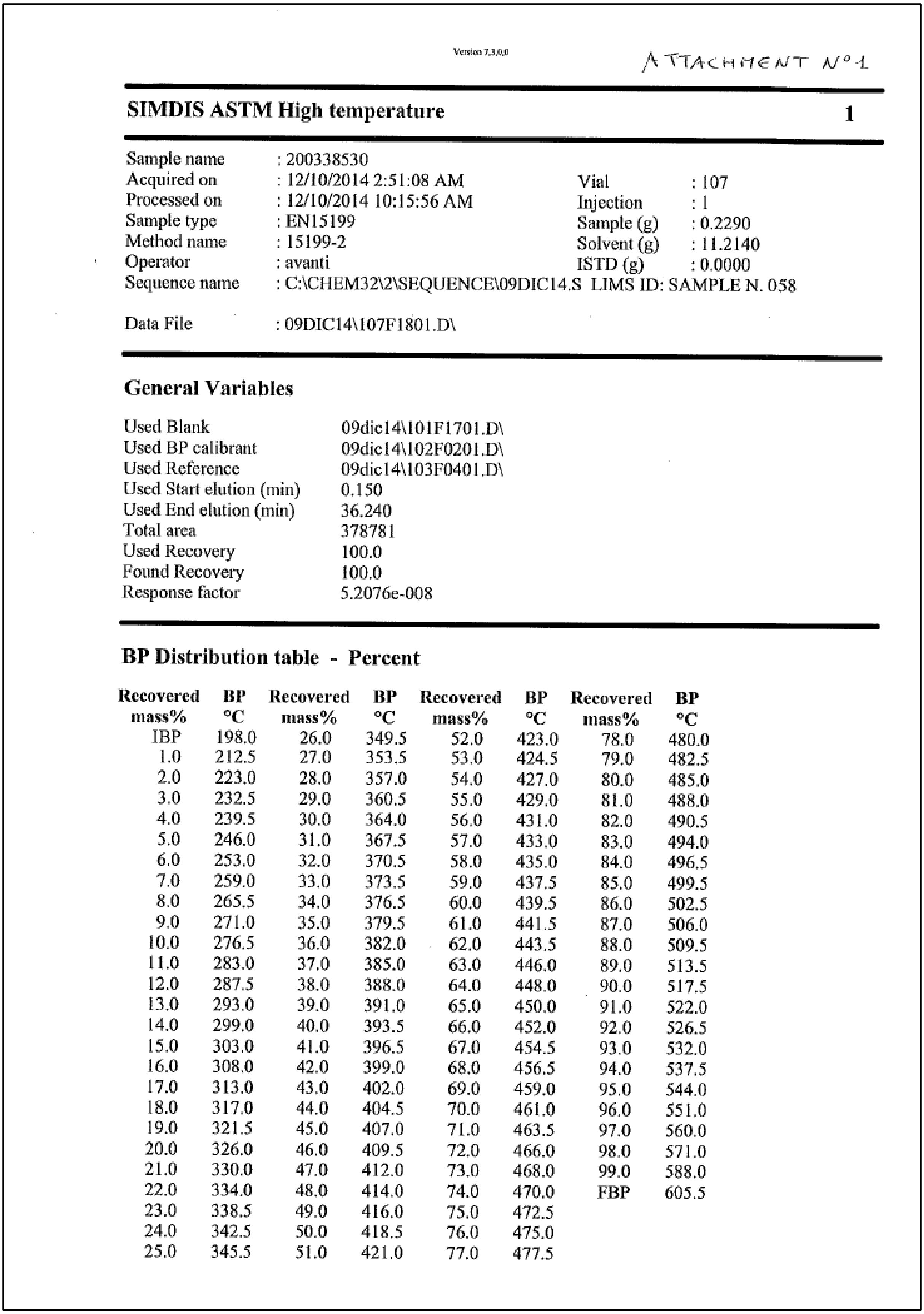
Issue date: December 22nd, 2014

SUPERVISOR	MANAGING DIRECTOR
Alessandro Bonini	Paolo Pollesel
ABonini	Paolo Pollesel



Version 7,3,0,0

ATTACHMENT N°1

SIMDIS ASTM High temperature

1

Sample name : 200338530
Acquired on : 12/10/2014 2:51:08 AM
Processed on : 12/10/2014 10:15:56 AM
Sample type : EN15199
Method name : 15199-2
Operator : avanti
Sequence name : C:\CHEM32\2\SEQUENCE\09DIC14.S LIMS ID: SAMPLE N. 058

Vial : 107
Injection : 1
Sample (g) : 0.2290
Solvent (g) : 11.2140
ISTD (g) : 0.0000

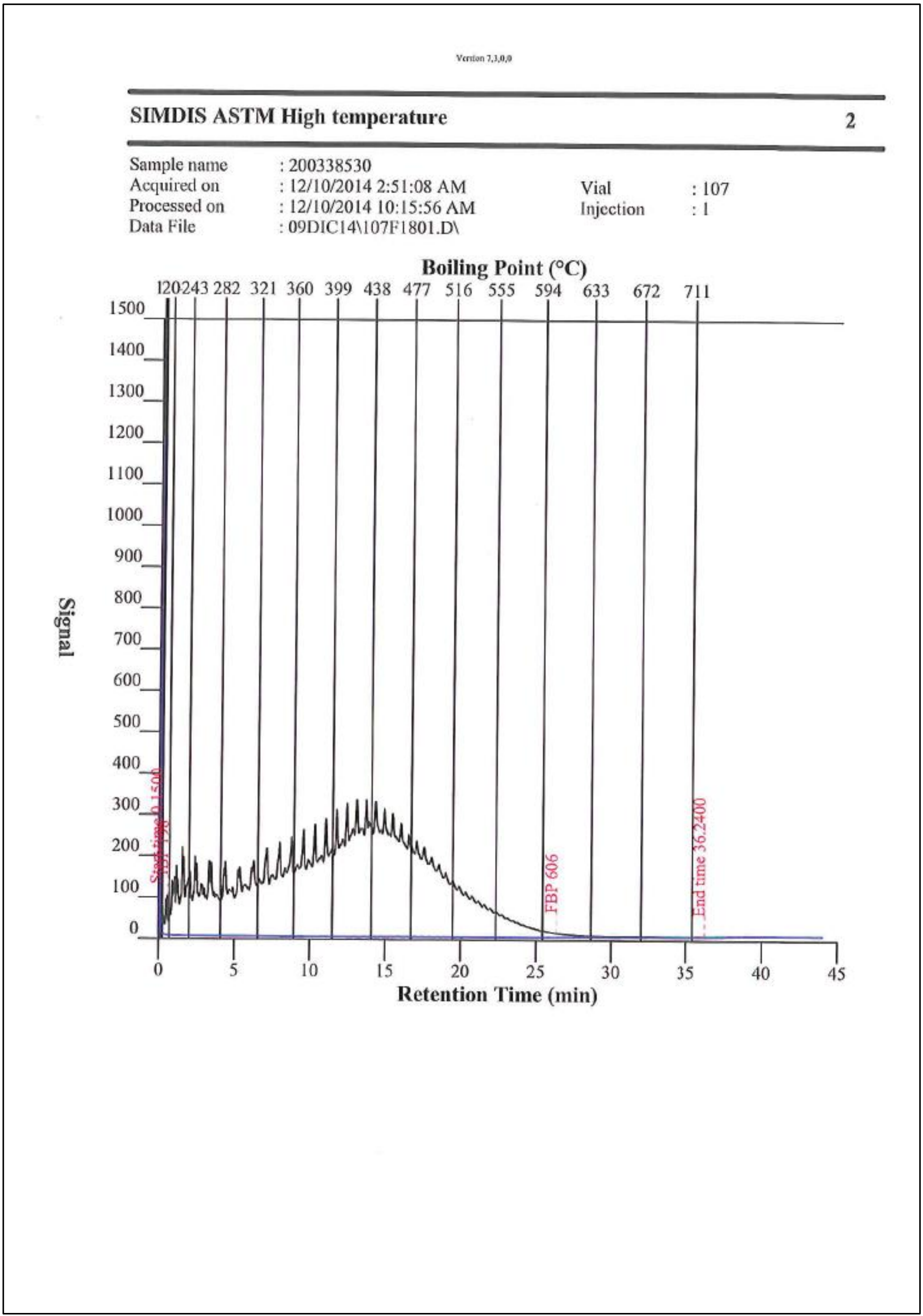
Data File : 09DIC14\107F1801.D\

General Variables

Used Blank	09dic14\101F1701.D\
Used BP calibrant	09dic14\102F0201.D\
Used Reference	09dic14\103F0401.D\
Used Start elution (min)	0.150
Used End elution (min)	36.240
Total area	378781
Used Recovery	100.0
Found Recovery	100.0
Response factor	5.2076e-008

BP Distribution table - Percent

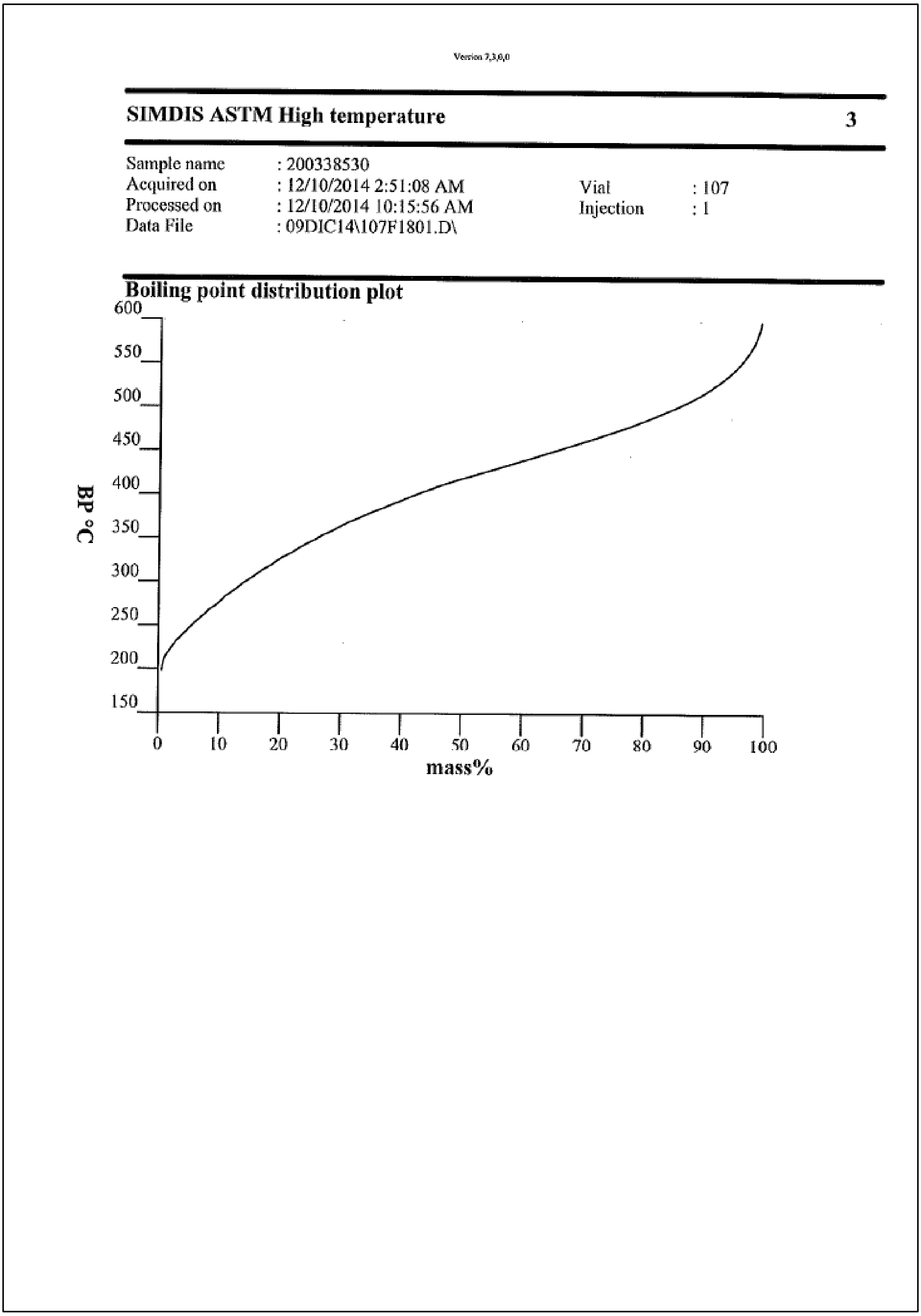
Recovered mass%	BP °C	Recovered mass%	BP °C	Recovered mass%	BP °C	Recovered mass%	BP °C
IBP	198.0	26.0	349.5	52.0	423.0	78.0	480.0
1.0	212.5	27.0	353.5	53.0	424.5	79.0	482.5
2.0	223.0	28.0	357.0	54.0	427.0	80.0	485.0
3.0	232.5	29.0	360.5	55.0	429.0	81.0	488.0
4.0	239.5	30.0	364.0	56.0	431.0	82.0	490.5
5.0	246.0	31.0	367.5	57.0	433.0	83.0	494.0
6.0	253.0	32.0	370.5	58.0	435.0	84.0	496.5
7.0	259.0	33.0	373.5	59.0	437.5	85.0	499.5
8.0	265.5	34.0	376.5	60.0	439.5	86.0	502.5
9.0	271.0	35.0	379.5	61.0	441.5	87.0	506.0
10.0	276.5	36.0	382.0	62.0	443.5	88.0	509.5
11.0	283.0	37.0	385.0	63.0	446.0	89.0	513.5
12.0	287.5	38.0	388.0	64.0	448.0	90.0	517.5
13.0	293.0	39.0	391.0	65.0	450.0	91.0	522.0
14.0	299.0	40.0	393.5	66.0	452.0	92.0	526.5
15.0	303.0	41.0	396.5	67.0	454.5	93.0	532.0
16.0	308.0	42.0	399.0	68.0	456.5	94.0	537.5
17.0	313.0	43.0	402.0	69.0	459.0	95.0	544.0
18.0	317.0	44.0	404.5	70.0	461.0	96.0	551.0
19.0	321.5	45.0	407.0	71.0	463.5	97.0	560.0
20.0	326.0	46.0	409.5	72.0	466.0	98.0	571.0
21.0	330.0	47.0	412.0	73.0	468.0	99.0	588.0
22.0	334.0	48.0	414.0	74.0	470.0	FBP	605.5
23.0	338.5	49.0	416.0	75.0	472.5		
24.0	342.5	50.0	418.5	76.0	475.0		
25.0	345.5	51.0	421.0	77.0	477.5		



Version 7,3,0,0

SIMDIS ASTM High temperature 2

Sample name : 200338530
Acquired on : 12/10/2014 2:51:08 AM
Processed on : 12/10/2014 10:15:56 AM
Data File : 09DIC14\107F1801.D\
Vial : 107
Injection : 1



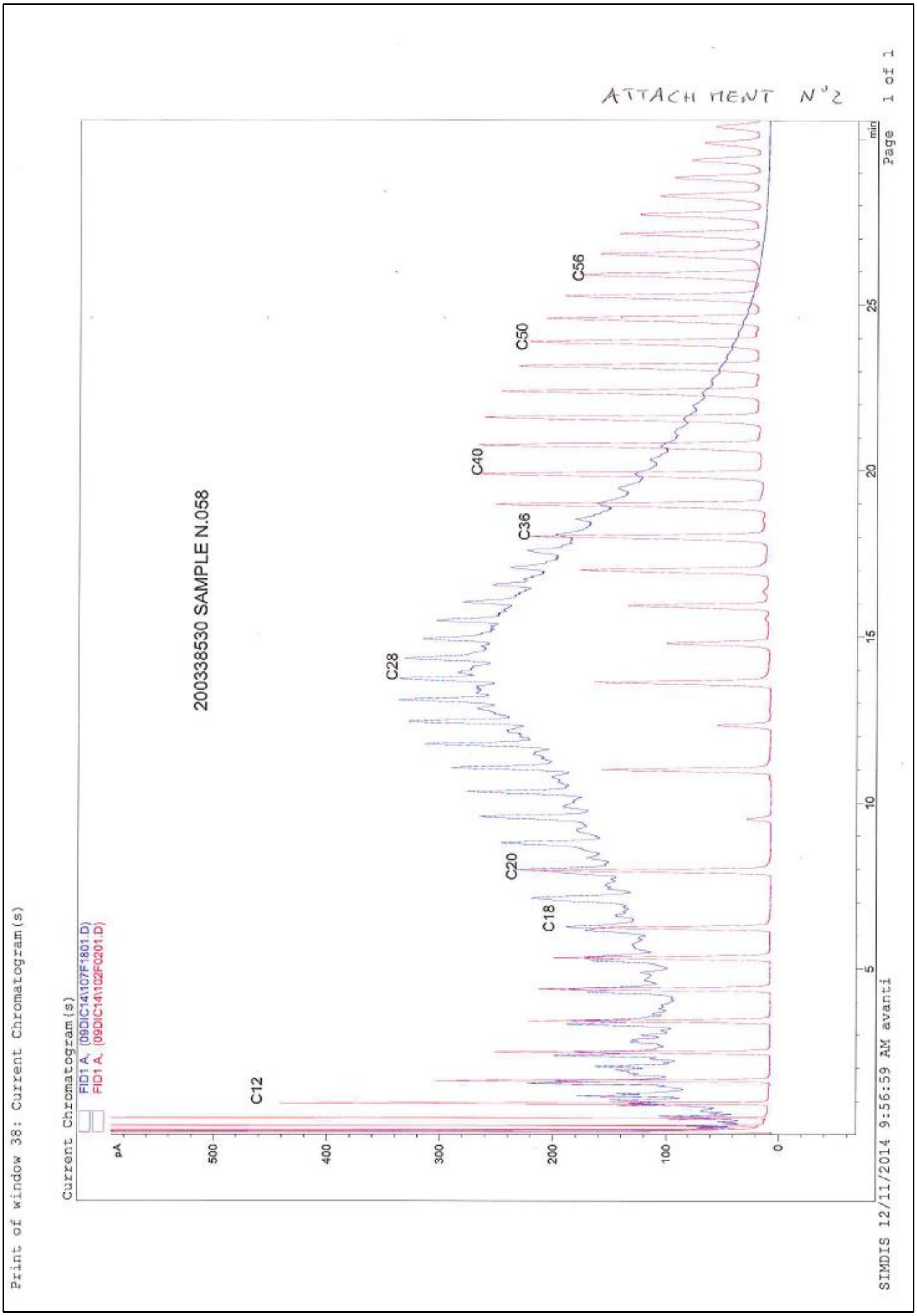
Version 7,3,0,0

SIMDIS ASTM High temperature 3

Sample name : 200338530
Acquired on : 12/10/2014 2:51:08 AM
Processed on : 12/10/2014 10:15:56 AM
Data File : 09DIC14\107F1801.D\

Vial : 107
Injection : 1

Boiling point distribution plot



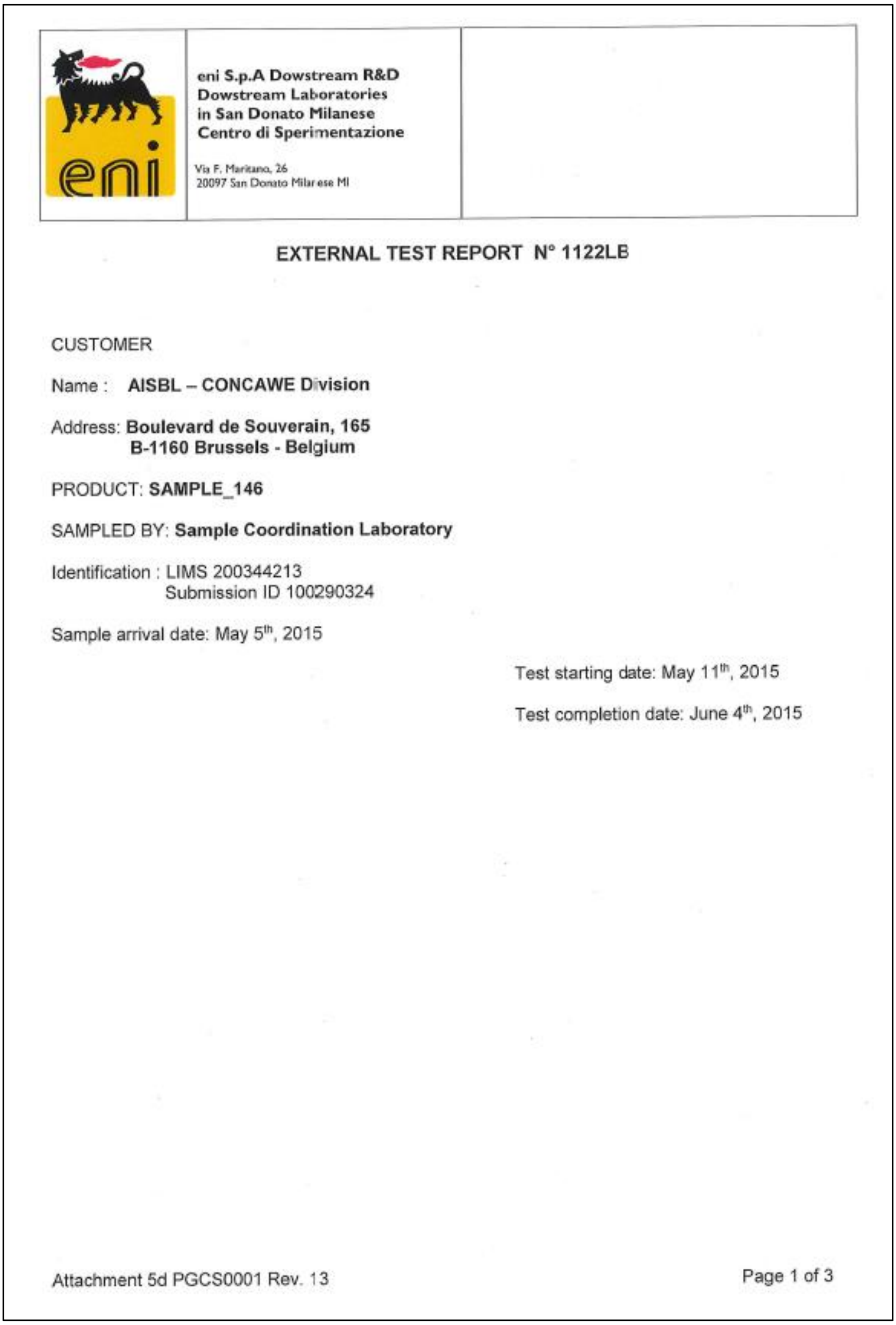
Print of window 38: Current Chromatogram(s)

ATTACHMENT N°2

SIMDIS 12/11/2014 9:56:59 AM avanti

Page 1 of 1

APPENDIX 7 - EXAMPLE OF DHA-GC AND PIONA-GC REPORT (SAMPLE 146 - LBPN)



eni S.p.A Dowstream R&D
Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

Via F. Maritano, 26
20097 San Donato Milanese MI

EXTERNAL TEST REPORT N° 1122LB

CUSTOMER

Name : **AISBL – CONCAWE Division**

Address: **Boulevard de Souverain, 165**
B-1160 Brussels - Belgium

PRODUCT: **SAMPLE_146**

SAMPLED BY: **Sample Coordination Laboratory**

Identification : LIMS 200344213
Submission ID 100290324

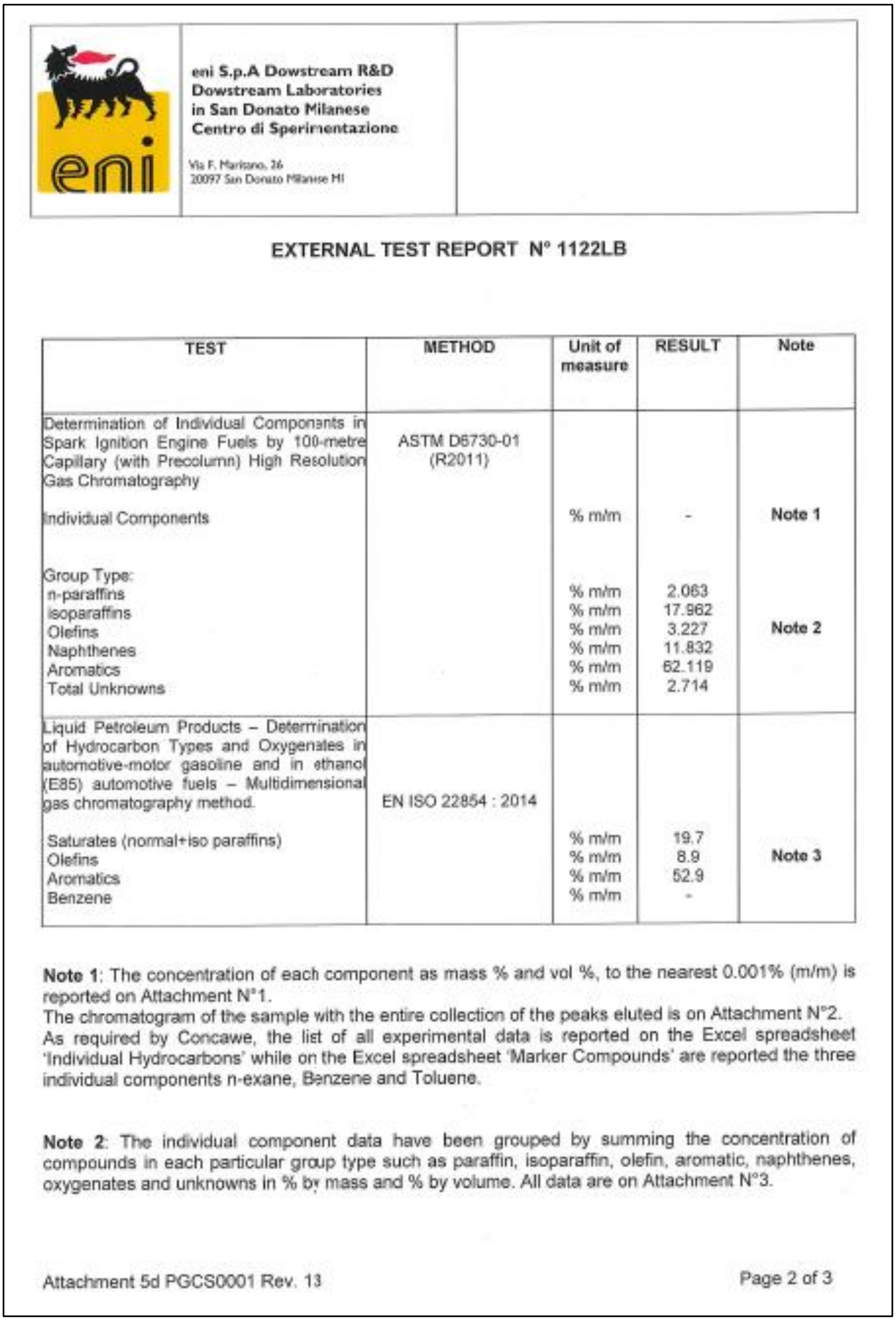
Sample arrival date: May 5th, 2015

Test starting date: May 11th, 2015

Test completion date: June 4th, 2015

Attachment 5d PGCS0001 Rev. 13

Page 1 of 3



eni S.p.A Dowstream R&D
Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

Via F. Maritano, 26
20097 San Donato Milanese MI

EXTERNAL TEST REPORT N° 1122LB

TEST	METHOD	Unit of measure	RESULT	Note
Determination of Individual Components in Spark Ignition Engine Fuels by 100-metre Capillary (with Precolumn) High Resolution Gas Chromatography	ASTM D6730-01 (R2011)			
Individual Components		% m/m	-	**Note 1**
Group Type:				
n-paraffins		% m/m	2.063	**Note 2**
isoparaffins		% m/m	17.962	
Olefins		% m/m	3.227	
Naphthenes		% m/m	11.832	
Aromatics		% m/m	62.119	
Total Unknowns		% m/m	2.714	
Liquid Petroleum Products – Determination of Hydrocarbon Types and Oxygenates in automotive-motor gasoline and in ethanol (E85) automotive fuels – Multidimensional gas chromatography method.	EN ISO 22854 : 2014			
Saturates (normal+iso paraffins)		% m/m	19.7	**Note 3**
Olefins		% m/m	8.9	
Aromatics		% m/m	52.9	
Benzene		% m/m	-	

Note 1: The concentration of each component as mass % and vol %, to the nearest 0.001% (m/m) is reported on Attachment N°1.
The chromatogram of the sample with the entire collection of the peaks eluted is on Attachment N°2.
As required by Concawe, the list of all experimental data is reported on the Excel spreadsheet 'Individual Hydrocarbons' while on the Excel spreadsheet 'Marker Compounds' are reported the three individual components n-exane, Benzene and Toluene.

Note 2: The individual component data have been grouped by summing the concentration of compounds in each particular group type such as paraffin, isoparaffin, olefin, aromatic, naphthenes, oxygenates and unknowns in % by mass and % by volume. All data are on Attachment N°3.

Attachment 5d PGCS0001 Rev. 13

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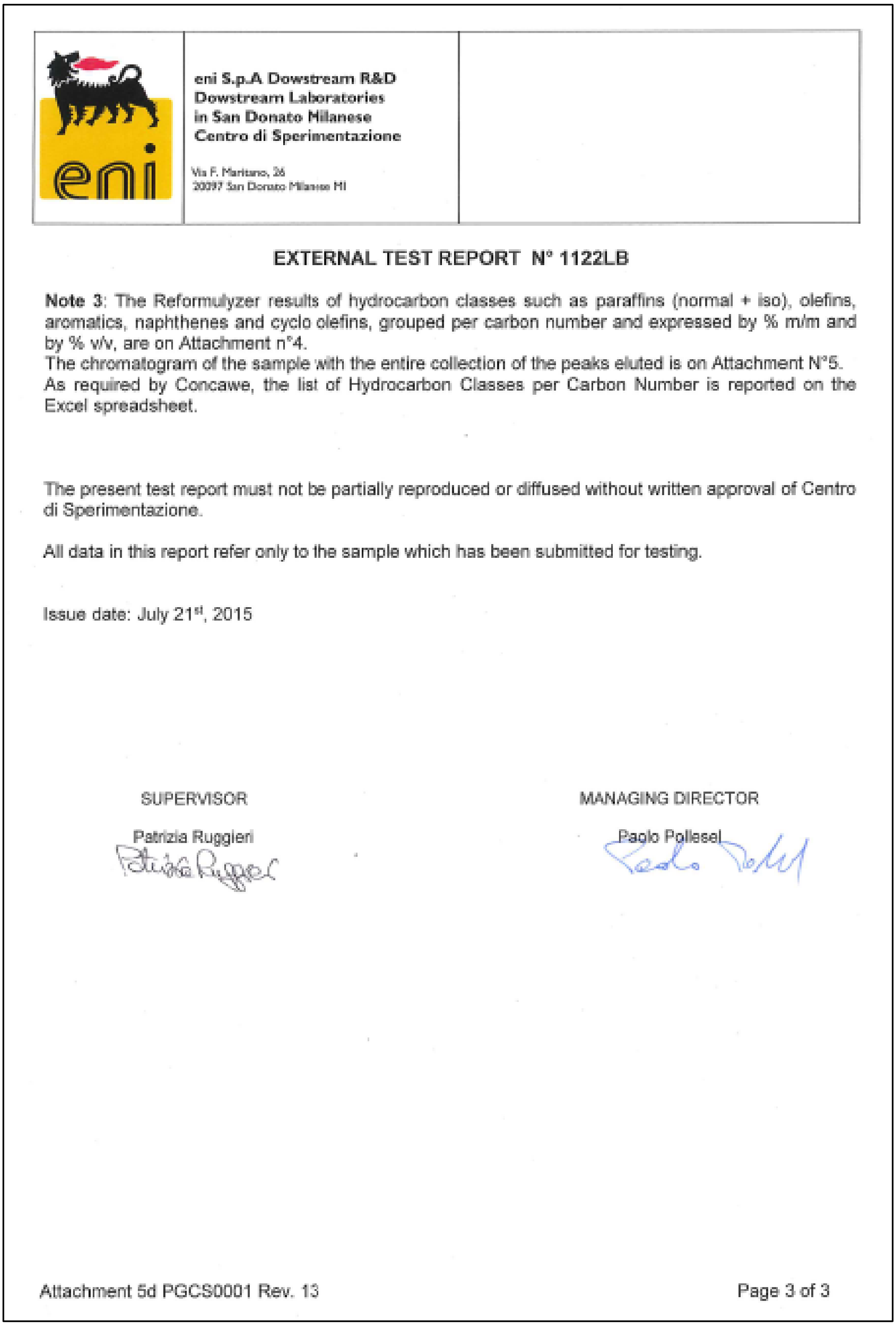


eni S.p.A Dowstream R&D
Dowstream Laboratories
in San Donato Milanese
Centro di Sperimentazione

Via F. Maritano, 26
20097 San Donato Milanese MI

EXTERNAL TEST REPORT N° 1122LB

Note 3: The Reformulyzer results of hydrocarbon classes such as paraffins (normal + iso), olefins, aromatics, naphthenes and cyclo olefins, grouped per carbon number and expressed by % m/m and by % v/v, are on Attachment n°4.
The chromatogram of the sample with the entire collection of the peaks eluted is on Attachment N°5.
As required by Concawe, the list of Hydrocarbon Classes per Carbon Number is reported on the Excel spreadsheet.

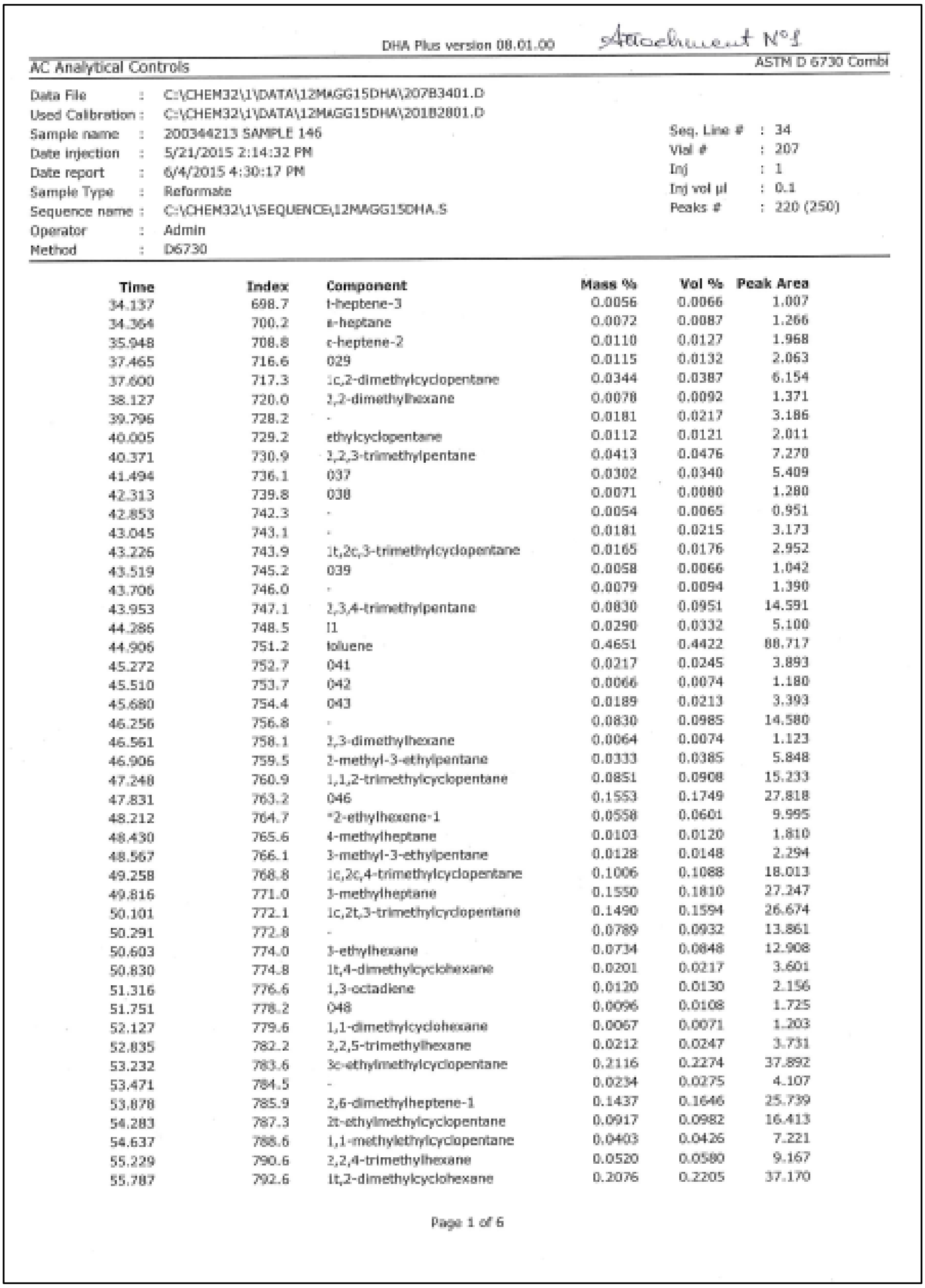
The present test report must not be partially reproduced or diffused without written approval of Centro di Sperimentazione.

All data in this report refer only to the sample which has been submitted for testing.

Issue date: July 21st, 2015

SUPERVISOR	MANAGING DIRECTOR
Patrizia Ruggieri	Paolo Pollesel

Attachment 5d PGCS0001 Rev. 13 Page 3 of 3



DHA Plus version 08.01.00

Attachment N°1

AC Analytical Controls

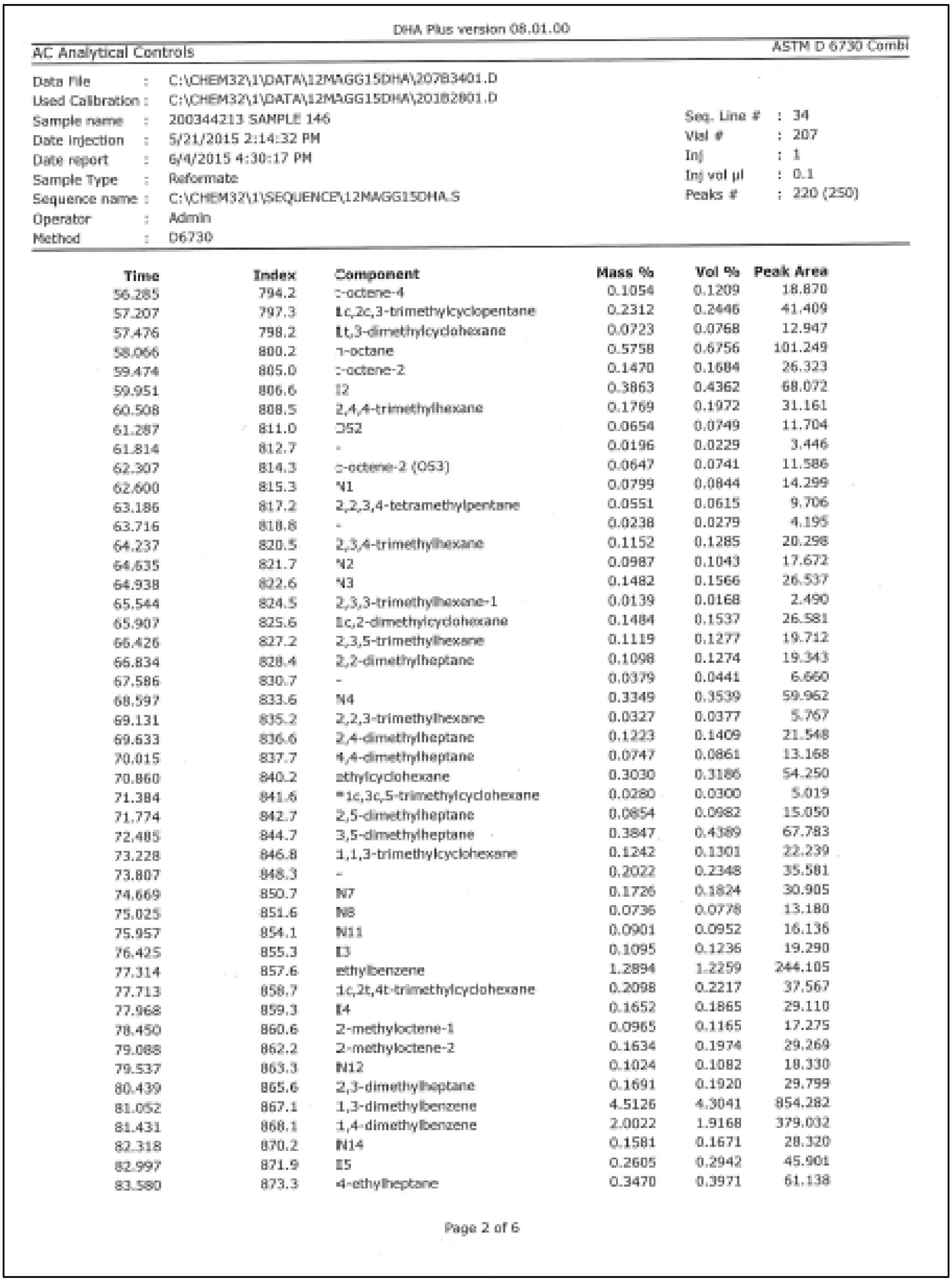
ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
34.137	698.7	t-heptene-3	0.0056	0.0066	1.007
34.364	700.2	n-heptane	0.0072	0.0087	1.266
35.948	708.8	c-heptene-2	0.0110	0.0127	1.968
37.465	716.6	029	0.0115	0.0132	2.063
37.600	717.3	1c,2-dimethylcyclopentane	0.0344	0.0387	6.154
38.127	720.0	2,2-dimethylhexane	0.0078	0.0092	1.371
39.796	728.2	-	0.0181	0.0217	3.186
40.005	729.2	ethylcyclopentane	0.0112	0.0121	2.011
40.371	730.9	2,2,3-trimethylpentane	0.0413	0.0476	7.270
41.494	736.1	037	0.0302	0.0340	5.409
42.313	739.8	038	0.0071	0.0080	1.280
42.853	742.3	-	0.0054	0.0065	0.951
43.045	743.1	-	0.0181	0.0215	3.173
43.226	743.9	1t,2c,3-trimethylcyclopentane	0.0165	0.0176	2.952
43.519	745.2	039	0.0058	0.0066	1.042
43.706	746.0	-	0.0079	0.0094	1.390
43.953	747.1	2,3,4-trimethylpentane	0.0830	0.0951	14.591
44.286	748.5	I1	0.0290	0.0332	5.100
44.906	751.2	toluene	0.4651	0.4422	88.717
45.272	752.7	041	0.0217	0.0245	3.893
45.510	753.7	042	0.0066	0.0074	1.180
45.680	754.4	043	0.0189	0.0213	3.393
46.256	756.8	-	0.0830	0.0985	14.580
46.561	758.1	2,3-dimethylhexane	0.0064	0.0074	1.123
46.906	759.5	2-methyl-3-ethylpentane	0.0333	0.0385	5.848
47.248	760.9	1,1,2-trimethylcyclopentane	0.0851	0.0908	15.233
47.831	763.2	046	0.1553	0.1749	27.818
48.212	764.7	*2-ethylhexene-1	0.0558	0.0601	9.995
48.430	765.6	4-methylheptane	0.0103	0.0120	1.810
48.567	766.1	3-methyl-3-ethylpentane	0.0128	0.0148	2.294
49.258	768.8	1c,2c,4-trimethylcyclopentane	0.1006	0.1088	18.013
49.816	771.0	3-methylheptane	0.1550	0.1810	27.247
50.101	772.1	1c,2t,3-trimethylcyclopentane	0.1490	0.1594	26.674
50.291	772.8	-	0.0789	0.0932	13.861
50.603	774.0	3-ethylhexane	0.0734	0.0848	12.908
50.830	774.8	1t,4-dimethylcyclohexane	0.0201	0.0217	3.601
51.316	776.6	1,3-octadiene	0.0120	0.0130	2.156
51.751	778.2	048	0.0096	0.0108	1.725
52.127	779.6	1,1-dimethylcyclohexane	0.0067	0.0071	1.203
52.835	782.2	2,2,5-trimethylhexane	0.0212	0.0247	3.731
53.232	783.6	3c-ethylmethylcyclopentane	0.2116	0.2274	37.892
53.471	784.5	-	0.0234	0.0275	4.107
53.878	785.9	2,6-dimethylheptene-1	0.1437	0.1646	25.739
54.283	787.3	2t-ethylmethylcyclopentane	0.0917	0.0982	16.413
54.637	788.6	1,1-methylethylcyclopentane	0.0403	0.0426	7.221
55.229	790.6	2,2,4-trimethylhexane	0.0520	0.0580	9.167
55.787	792.6	1t,2-dimethylcyclohexane	0.2076	0.2205	37.170

Page 1 of 6



DHA Plus version 08.01.00

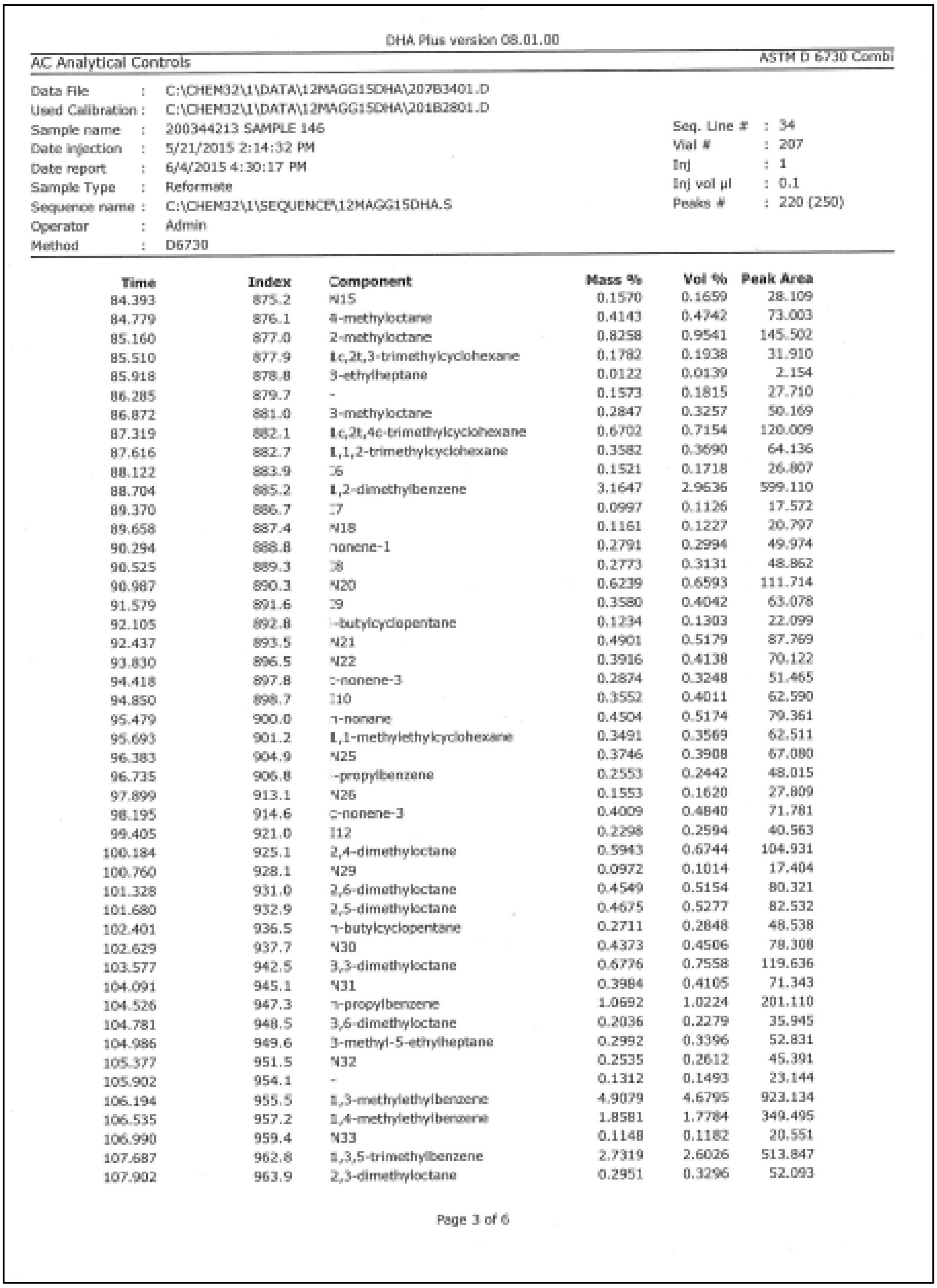
AC Analytical Controls ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
56.285	794.2	c-octene-4	0.1054	0.1209	18.870
57.207	797.3	1c,2c,3-trimethylcyclopentane	0.2312	0.2446	41.409
57.476	798.2	1t,3-dimethylcyclohexane	0.0723	0.0768	12.947
58.066	800.2	n-octane	0.5758	0.6756	101.249
59.474	805.0	c-octene-2	0.1470	0.1684	26.323
59.951	806.6	E2	0.3863	0.4362	68.072
60.508	808.5	2,4,4-trimethylhexane	0.1769	0.1972	31.161
61.287	811.0	OS2	0.0654	0.0749	11.704
61.814	812.7	-	0.0196	0.0229	3.446
62.307	814.3	c-octene-2 (OS3)	0.0647	0.0741	11.586
62.600	815.3	N1	0.0799	0.0844	14.299
63.186	817.2	2,2,3,4-tetramethylpentane	0.0551	0.0615	9.706
63.716	818.8	-	0.0238	0.0279	4.195
64.237	820.5	2,3,4-trimethylhexane	0.1152	0.1285	20.298
64.635	821.7	N2	0.0987	0.1043	17.672
64.938	822.6	N3	0.1482	0.1566	26.537
65.544	824.5	2,3,3-trimethylhexene-1	0.0139	0.0168	2.490
65.907	825.6	1c,2-dimethylcyclohexane	0.1484	0.1537	26.581
66.426	827.2	2,3,5-trimethylhexane	0.1119	0.1277	19.712
66.834	828.4	2,2-dimethylheptane	0.1098	0.1274	19.343
67.586	830.7	-	0.0379	0.0441	6.660
68.597	833.6	N4	0.3349	0.3539	59.962
69.131	835.2	2,2,3-trimethylhexane	0.0327	0.0377	5.767
69.633	836.6	2,4-dimethylheptane	0.1223	0.1409	21.548
70.015	837.7	4,4-dimethylheptane	0.0747	0.0861	13.168
70.860	840.2	ethylcyclohexane	0.3030	0.3186	54.250
71.384	841.6	*1c,3c,5-trimethylcyclohexane	0.0280	0.0300	5.019
71.774	842.7	2,5-dimethylheptane	0.0854	0.0982	15.050
72.485	844.7	3,5-dimethylheptane	0.3847	0.4389	67.783
73.228	846.8	1,1,3-trimethylcyclohexane	0.1242	0.1301	22.239
73.807	848.3	-	0.2022	0.2348	35.581
74.669	850.7	N7	0.1726	0.1824	30.905
75.025	851.6	N8	0.0736	0.0778	13.180
75.957	854.1	N11	0.0901	0.0952	16.136
76.425	855.3	E3	0.1095	0.1236	19.290
77.314	857.6	ethylbenzene	1.2894	1.2259	244.105
77.713	858.7	1c,2t,4t-trimethylcyclohexane	0.2098	0.2217	37.567
77.968	859.3	E4	0.1652	0.1865	29.110
78.450	860.6	2-methyloctene-1	0.0965	0.1165	17.275
79.088	862.2	2-methyloctene-2	0.1634	0.1974	29.269
79.537	863.3	N12	0.1024	0.1082	18.330
80.439	865.6	2,3-dimethylheptane	0.1691	0.1920	29.799
81.052	867.1	1,3-dimethylbenzene	4.5126	4.3041	854.282
81.431	868.1	1,4-dimethylbenzene	2.0022	1.9168	379.032
82.318	870.2	N14	0.1581	0.1671	28.320
82.997	871.9	E5	0.2605	0.2942	45.901
83.580	873.3	4-ethylheptane	0.3470	0.3971	61.138

Page 2 of 6



DHA Plus version 08.01.00

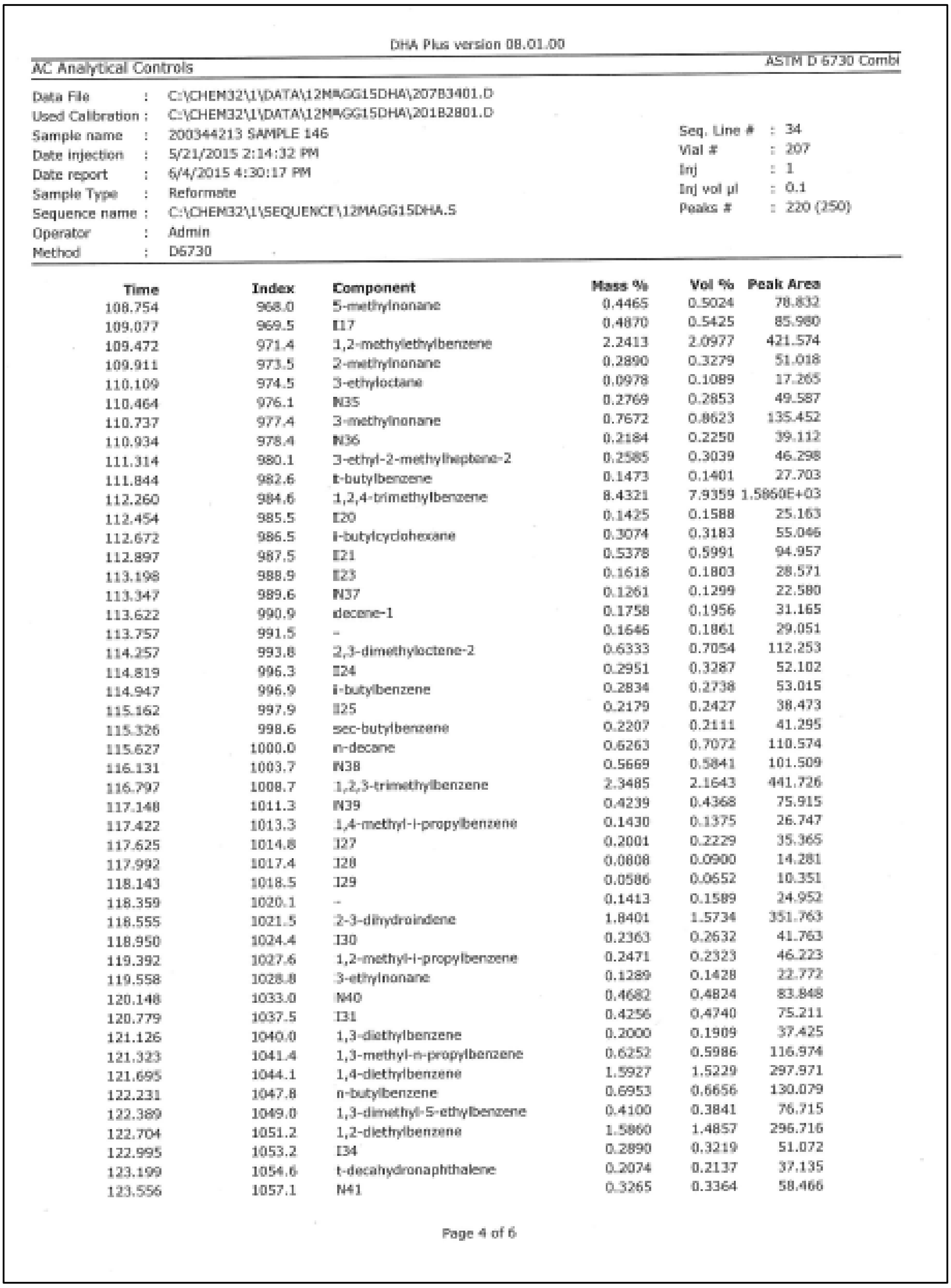
AC Analytical Controls ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
84.393	875.2	N15	0.1570	0.1659	28.109
84.779	876.1	4-methyloctane	0.4143	0.4742	73.003
85.160	877.0	2-methyloctane	0.8258	0.9541	145.502
85.510	877.9	1c,2t,3-trimethylcyclohexane	0.1782	0.1938	31.910
85.918	878.8	3-ethylheptane	0.0122	0.0139	2.154
86.285	879.7	-	0.1573	0.1815	27.710
86.872	881.0	3-methyloctane	0.2847	0.3257	50.169
87.319	882.1	1c,2t,4c-trimethylcyclohexane	0.6702	0.7154	120.009
87.616	882.7	1,1,2-trimethylcyclohexane	0.3582	0.3690	64.136
88.122	883.9	I6	0.1521	0.1718	26.807
88.704	885.2	1,2-dimethylbenzene	3.1647	2.9636	599.110
89.370	886.7	I7	0.0997	0.1126	17.572
89.658	887.4	N18	0.1161	0.1227	20.797
90.294	888.8	nonene-1	0.2791	0.2994	49.974
90.525	889.3	I8	0.2773	0.3131	48.862
90.987	890.3	N20	0.6239	0.6593	111.714
91.579	891.6	I9	0.3580	0.4042	63.078
92.105	892.8	i-butylcyclopentane	0.1234	0.1303	22.099
92.437	893.5	N21	0.4901	0.5179	87.769
93.830	896.5	N22	0.3916	0.4138	70.122
94.418	897.8	c-nonene-3	0.2874	0.3248	51.465
94.850	898.7	I10	0.3552	0.4011	62.590
95.479	900.0	n-nonane	0.4504	0.5174	79.361
95.693	901.2	1,1-methylethylcyclohexane	0.3491	0.3569	62.511
96.383	904.9	N25	0.3746	0.3908	67.080
96.735	906.8	i-propylbenzene	0.2553	0.2442	48.015
97.899	913.1	N26	0.1553	0.1620	27.809
98.195	914.6	c-nonene-3	0.4009	0.4840	71.781
99.405	921.0	I12	0.2298	0.2594	40.563
100.184	925.1	2,4-dimethyloctane	0.5943	0.6744	104.931
100.760	928.1	N29	0.0972	0.1014	17.404
101.328	931.0	2,6-dimethyloctane	0.4549	0.5154	80.321
101.680	932.9	2,5-dimethyloctane	0.4675	0.5277	82.532
102.401	936.5	n-butylcyclopentane	0.2711	0.2848	48.538
102.629	937.7	N30	0.4373	0.4506	78.308
103.577	942.5	3,3-dimethyloctane	0.6776	0.7558	119.636
104.091	945.1	N31	0.3984	0.4105	71.343
104.526	947.3	n-propylbenzene	1.0692	1.0224	201.110
104.781	948.5	3,6-dimethyloctane	0.2036	0.2279	35.945
104.986	949.6	3-methyl-5-ethylheptane	0.2992	0.3396	52.831
105.377	951.5	N32	0.2535	0.2612	45.391
105.902	954.1	-	0.1312	0.1493	23.144
106.194	955.5	1,3-methylethylbenzene	4.9079	4.6795	923.134
106.535	957.2	1,4-methylethylbenzene	1.8581	1.7784	349.495
106.990	959.4	N33	0.1148	0.1182	20.551
107.687	962.8	1,3,5-trimethylbenzene	2.7319	2.6026	513.847
107.902	963.9	2,3-dimethyloctane	0.2951	0.3296	52.093

Page 3 of 6



DHA Plus version 08.01.00

AC Analytical Controls

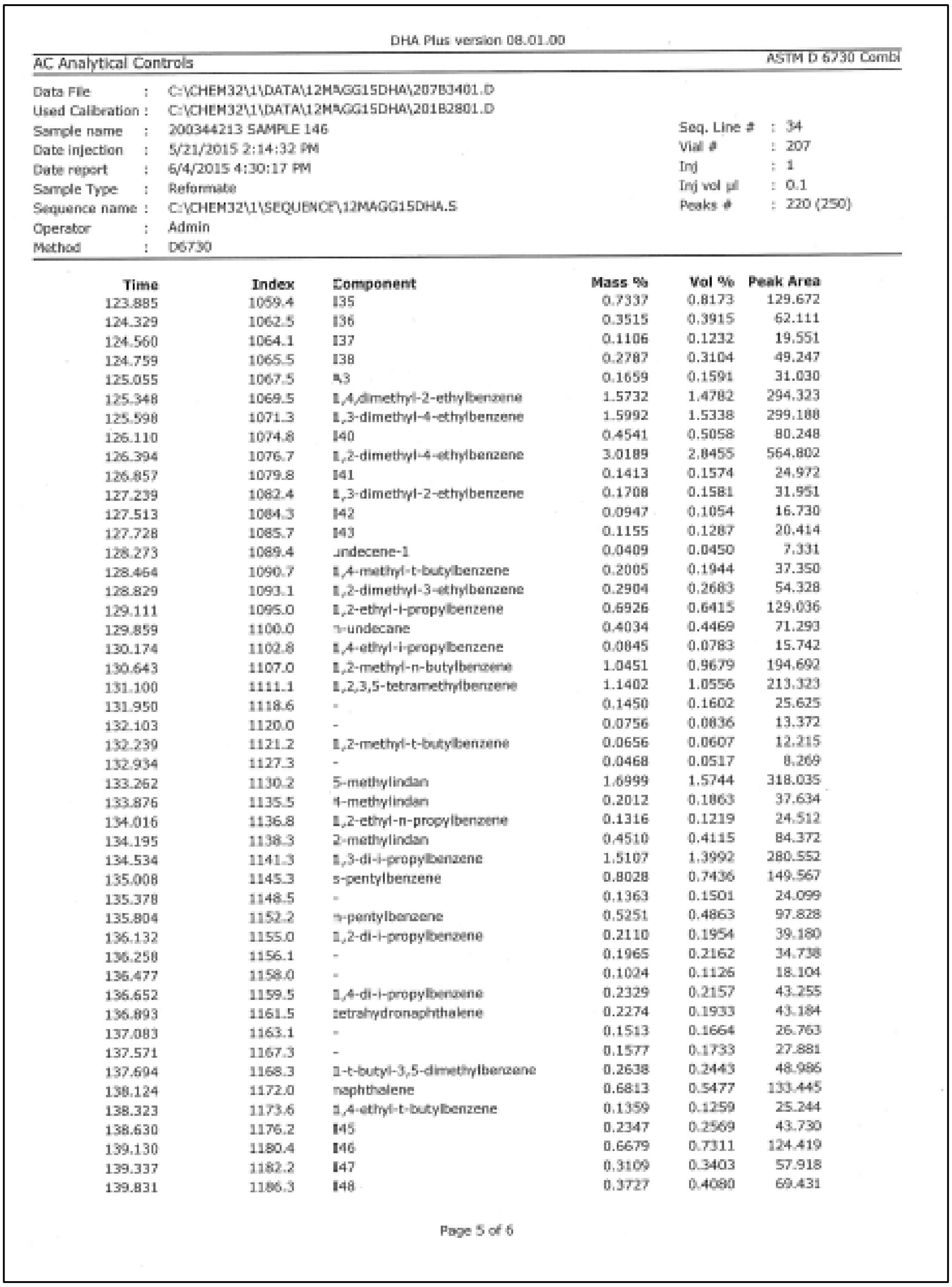
ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
108.754	968.0	5-methylnonane	0.4465	0.5024	78.832
109.077	969.5	I17	0.4870	0.5425	85.980
109.472	971.4	1,2-methylethylbenzene	2.2413	2.0977	421.574
109.911	973.5	2-methylnonane	0.2890	0.3279	51.018
110.109	974.5	3-ethyloctane	0.0978	0.1089	17.265
110.464	976.1	N35	0.2769	0.2853	49.587
110.737	977.4	3-methylnonane	0.7672	0.8623	135.452
110.934	978.4	N36	0.2184	0.2250	39.112
111.314	980.1	3-ethyl-2-methylheptene-2	0.2585	0.3039	46.298
111.844	982.6	t-butylbenzene	0.1473	0.1401	27.703
112.260	984.6	1,2,4-trimethylbenzene	8.4321	7.9359	1.5860E+03
112.454	985.5	I20	0.1425	0.1588	25.163
112.672	986.5	i-butylcyclohexane	0.3074	0.3183	55.046
112.897	987.5	I21	0.5378	0.5991	94.957
113.198	988.9	I23	0.1618	0.1803	28.571
113.347	989.6	N37	0.1261	0.1299	22.580
113.622	990.9	decene-1	0.1758	0.1956	31.165
113.757	991.5	-	0.1646	0.1861	29.051
114.257	993.8	2,3-dimethyloctene-2	0.6333	0.7054	112.253
114.819	996.3	I24	0.2951	0.3287	52.102
114.947	996.9	i-butylbenzene	0.2834	0.2738	53.015
115.162	997.9	I25	0.2179	0.2427	38.473
115.326	998.6	sec-butylbenzene	0.2207	0.2111	41.295
115.627	1000.0	n-decane	0.6263	0.7072	110.574
116.131	1003.7	N38	0.5669	0.5841	101.509
116.797	1008.7	1,2,3-trimethylbenzene	2.3485	2.1643	441.726
117.148	1011.3	N39	0.4239	0.4368	75.915
117.422	1013.3	1,4-methyl-i-propylbenzene	0.1430	0.1375	26.747
117.625	1014.8	I27	0.2001	0.2229	35.365
117.992	1017.4	I28	0.0808	0.0900	14.281
118.143	1018.5	I29	0.0586	0.0652	10.351
118.359	1020.1	-	0.1413	0.1589	24.952
118.555	1021.5	2-3-dihydroindene	1.8401	1.5734	351.763
118.950	1024.4	I30	0.2363	0.2632	41.763
119.392	1027.6	1,2-methyl-i-propylbenzene	0.2471	0.2323	46.223
119.558	1028.8	3-ethylnonane	0.1289	0.1428	22.772
120.148	1033.0	N40	0.4682	0.4824	83.848
120.779	1037.5	I31	0.4256	0.4740	75.211
121.126	1040.0	1,3-diethylbenzene	0.2000	0.1909	37.425
121.323	1041.4	1,3-methyl-n-propylbenzene	0.6252	0.5986	116.974
121.695	1044.1	1,4-diethylbenzene	1.5927	1.5229	297.971
122.231	1047.8	n-butylbenzene	0.6953	0.6656	130.079
122.389	1049.0	1,3-dimethyl-5-ethylbenzene	0.4100	0.3841	76.715
122.704	1051.2	1,2-diethylbenzene	1.5860	1.4857	296.716
122.995	1053.2	I34	0.2890	0.3219	51.072
123.199	1054.6	t-decahydronaphthalene	0.2074	0.2137	37.135
123.556	1057.1	N41	0.3265	0.3364	58.466

Page 4 of 6



DHA Plus version 08.01.00

AC Analytical Controls — ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
123.885	1059.4	I35	0.7337	0.8173	129.672
124.329	1062.5	I36	0.3515	0.3915	62.111
124.560	1064.1	I37	0.1106	0.1232	19.551
124.759	1065.5	I38	0.2787	0.3104	49.247
125.055	1067.5	N3	0.1659	0.1591	31.030
125.348	1069.5	1,4-dimethyl-2-ethylbenzene	1.5732	1.4782	294.323
125.598	1071.3	1,3-dimethyl-4-ethylbenzene	1.5992	1.5338	299.188
126.110	1074.8	I40	0.4541	0.5058	80.248
126.394	1076.7	1,2-dimethyl-4-ethylbenzene	3.0189	2.8455	564.802
126.857	1079.8	I41	0.1413	0.1574	24.972
127.239	1082.4	1,3-dimethyl-2-ethylbenzene	0.1708	0.1581	31.951
127.513	1084.3	I42	0.0947	0.1054	16.730
127.728	1085.7	I43	0.1155	0.1287	20.414
128.273	1089.4	undecene-1	0.0409	0.0450	7.331
128.464	1090.7	1,4-methyl-t-butylbenzene	0.2005	0.1944	37.350
128.829	1093.1	1,2-dimethyl-3-ethylbenzene	0.2904	0.2683	54.328
129.111	1095.0	1,2-ethyl-i-propylbenzene	0.6926	0.6415	129.036
129.859	1100.0	n-undecane	0.4034	0.4469	71.293
130.174	1102.8	1,4-ethyl-i-propylbenzene	0.0845	0.0783	15.742
130.643	1107.0	1,2-methyl-n-butylbenzene	1.0451	0.9679	194.692
131.100	1111.1	1,2,3,5-tetramethylbenzene	1.1402	1.0556	213.323
131.950	1118.6	-	0.1450	0.1602	25.625
132.103	1120.0	-	0.0756	0.0836	13.372
132.239	1121.2	1,2-methyl-t-butylbenzene	0.0656	0.0607	12.215
132.934	1127.3	-	0.0468	0.0517	8.269
133.262	1130.2	5-methylindan	1.6999	1.5744	318.035
133.876	1135.5	4-methylindan	0.2012	0.1863	37.634
134.016	1136.8	1,2-ethyl-n-propylbenzene	0.1316	0.1219	24.512
134.195	1138.3	2-methylindan	0.4510	0.4115	84.372
134.534	1141.3	1,3-di-i-propylbenzene	1.5107	1.3992	280.552
135.008	1145.3	s-pentylbenzene	0.8028	0.7436	149.567
135.378	1148.5	-	0.1363	0.1501	24.099
135.804	1152.2	n-pentylbenzene	0.5251	0.4863	97.828
136.132	1155.0	1,2-di-i-propylbenzene	0.2110	0.1954	39.180
136.258	1156.1	-	0.1965	0.2162	34.738
136.477	1158.0	-	0.1024	0.1126	18.104
136.652	1159.5	1,4-di-i-propylbenzene	0.2329	0.2157	43.255
136.893	1161.5	tetrahydronaphthalene	0.2274	0.1933	43.184
137.083	1163.1	-	0.1513	0.1664	26.763
137.571	1167.3	-	0.1577	0.1733	27.881
137.694	1168.3	1-t-butyl-3,5-dimethylbenzene	0.2638	0.2443	48.986
138.124	1172.0	naphthalene	0.6813	0.5477	133.445
138.323	1173.6	1,4-ethyl-t-butylbenzene	0.1359	0.1259	25.244
138.630	1176.2	I45	0.2347	0.2569	43.730
139.130	1180.4	I46	0.6679	0.7311	124.419
139.337	1182.2	I47	0.3109	0.3403	57.918
139.831	1186.3	I48	0.3727	0.4080	69.431

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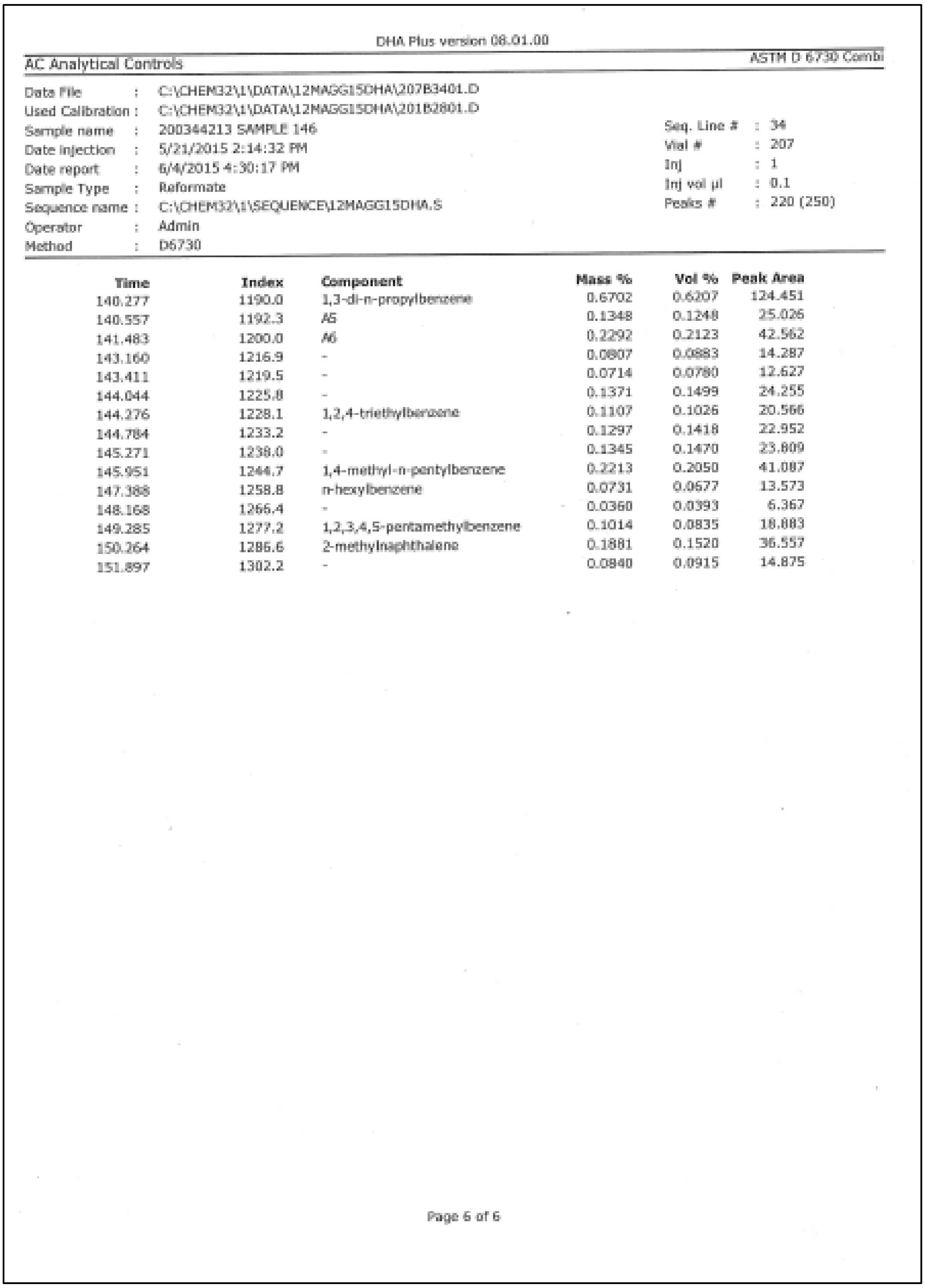

DHA Plus version 08.01.00

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Time	Index	Component	Mass %	Vol %	Peak Area
140.277	1190.0	1,3-di-n-propylbenzene	0.6702	0.6207	124.451
140.557	1192.3	A5	0.1348	0.1248	25.026
141.483	1200.0	A6	0.2292	0.2123	42.562
143.160	1216.9	-	0.0807	0.0883	14.287
143.411	1219.5	-	0.0714	0.0780	12.627
144.044	1225.8	-	0.1371	0.1499	24.255
144.276	1228.1	1,2,4-triethylbenzene	0.1107	0.1026	20.566
144.784	1233.2	-	0.1297	0.1418	22.952
145.271	1238.0	-	0.1345	0.1470	23.809
145.951	1244.7	1,4-methyl-n-pentylbenzene	0.2213	0.2050	41.087
147.388	1258.8	n-hexylbenzene	0.0731	0.0677	13.573
148.168	1266.4	-	0.0360	0.0393	6.367
149.285	1277.2	1,2,3,4,5-pentamethylbenzene	0.1014	0.0835	18.883
150.264	1286.6	2-methylnaphthalene	0.1881	0.1520	36.557
151.897	1302.2	-	0.0840	0.0915	14.875

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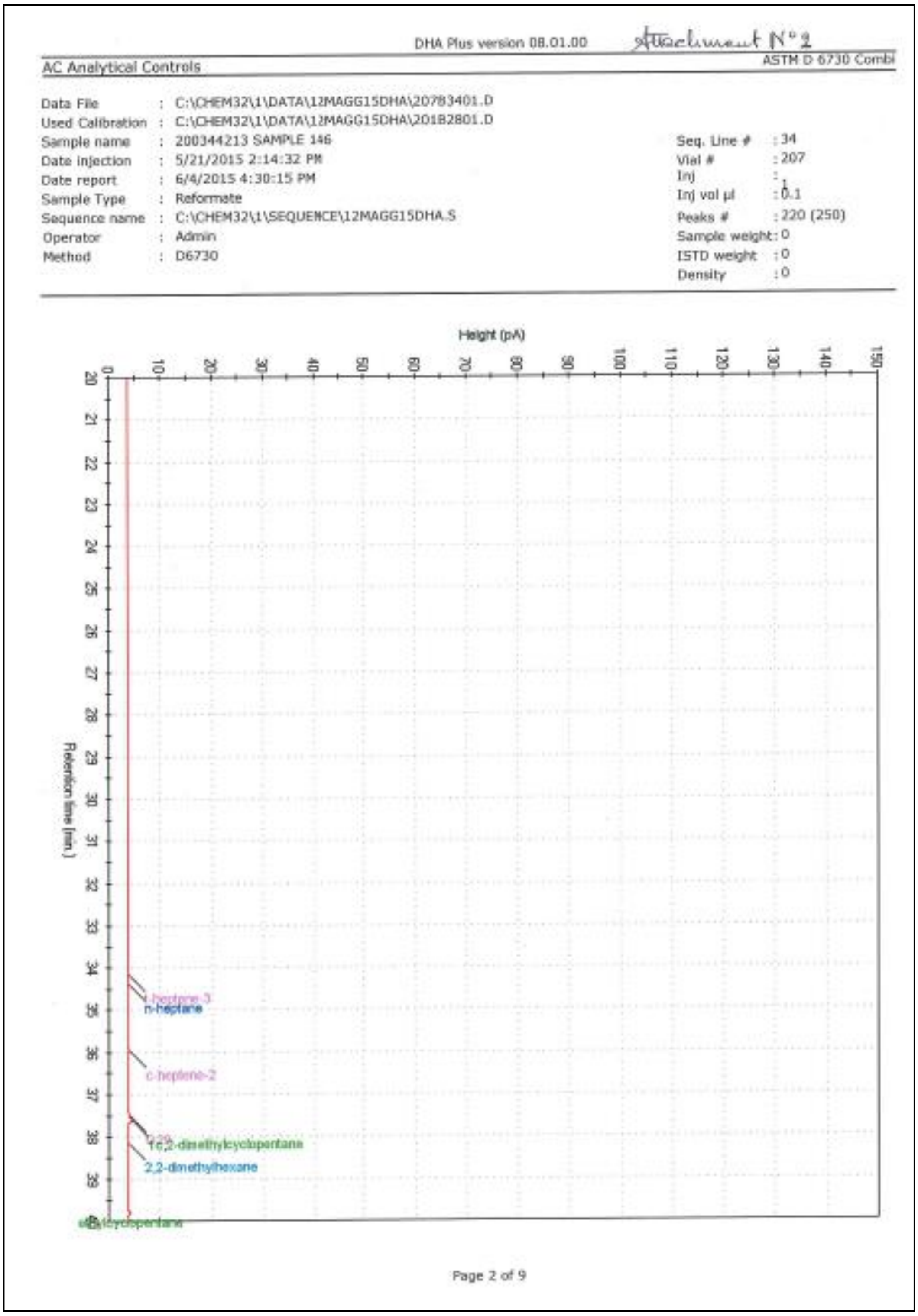

DHA Plus version 08.01.00 Attachment N°2

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\20783401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\20182801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight : 0
ISTD weight : 0
Density : 0

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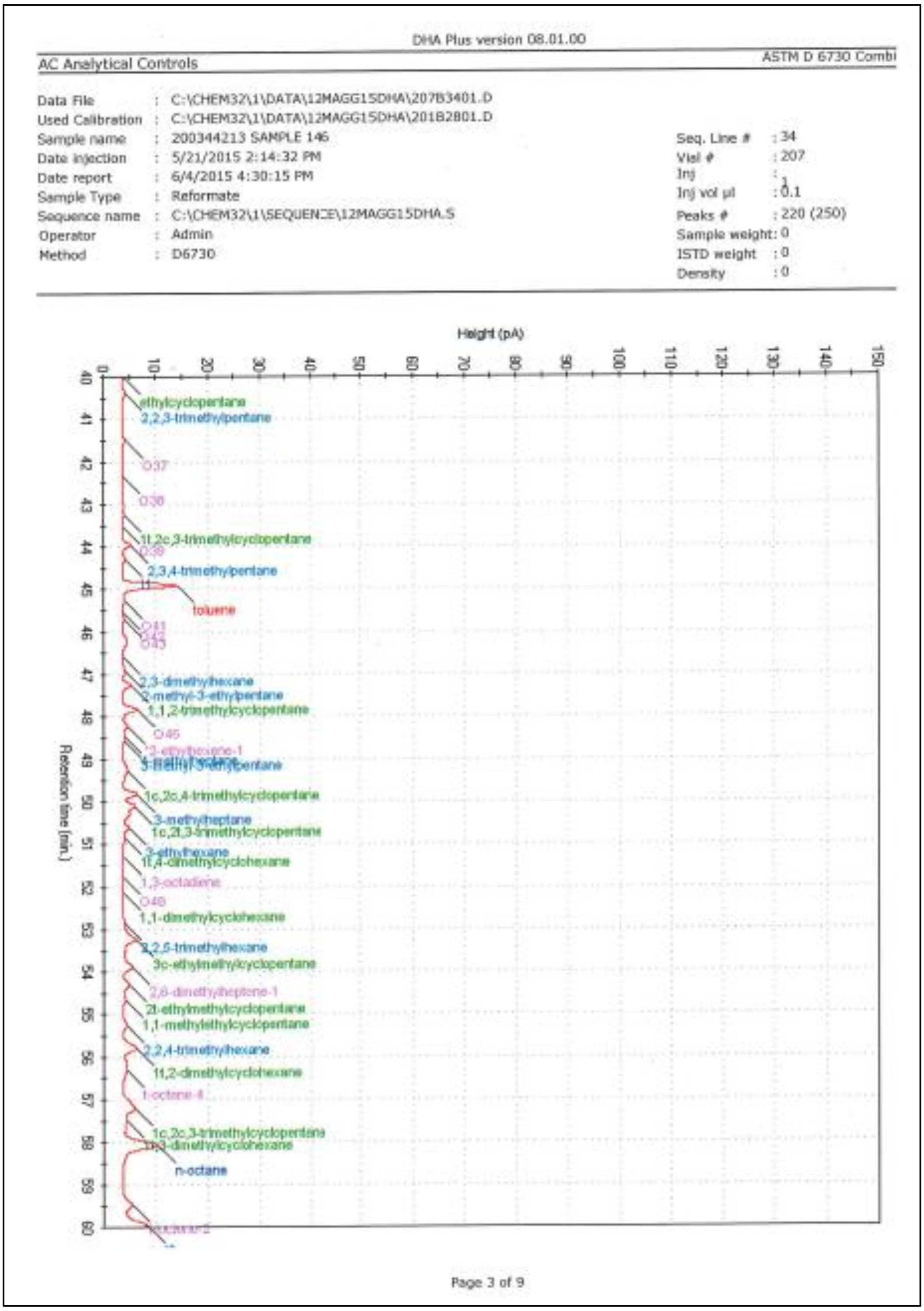


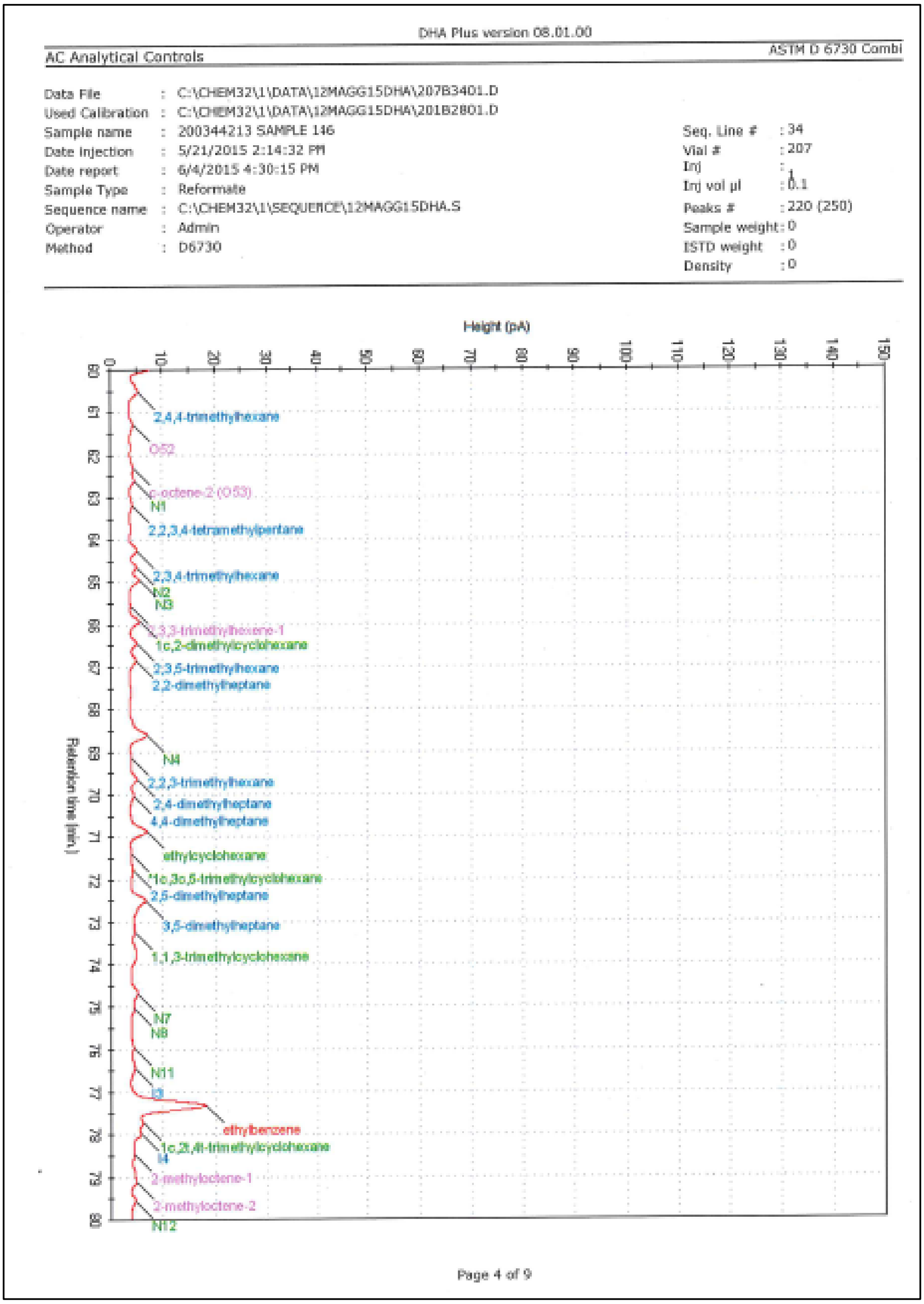
DHA Plus version 08.01.00

AC Analytical Controls ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight: 0
ISTD weight : 0
Density : 0

Page 3 of 9



DHA Plus version 08.01.00

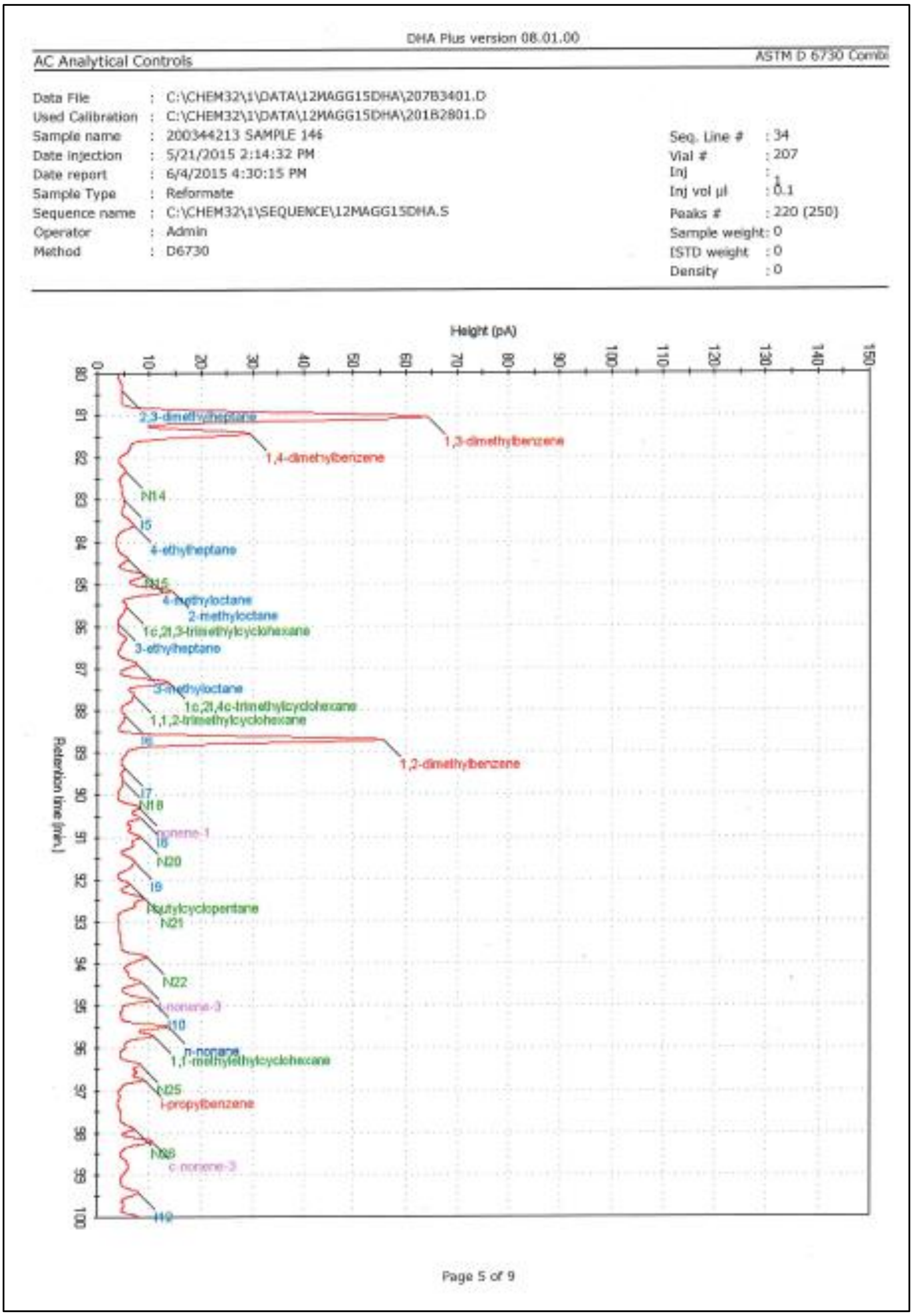
AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight : 0
ISTD weight : 0
Density : 0

Page 4 of 9



DHA Plus version 08.01.00

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight: 0
ISTD weight : 0
Density : 0

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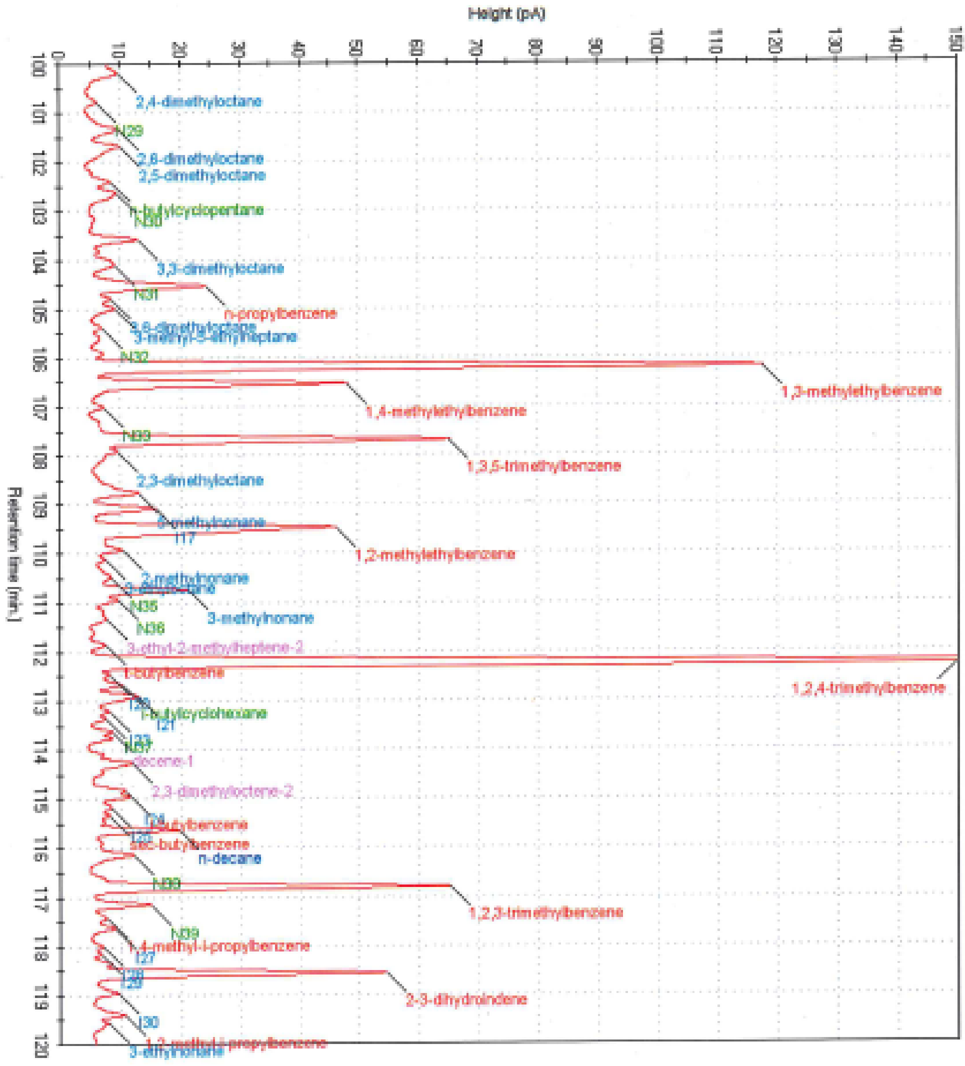
DHA Plus version 08.01.00

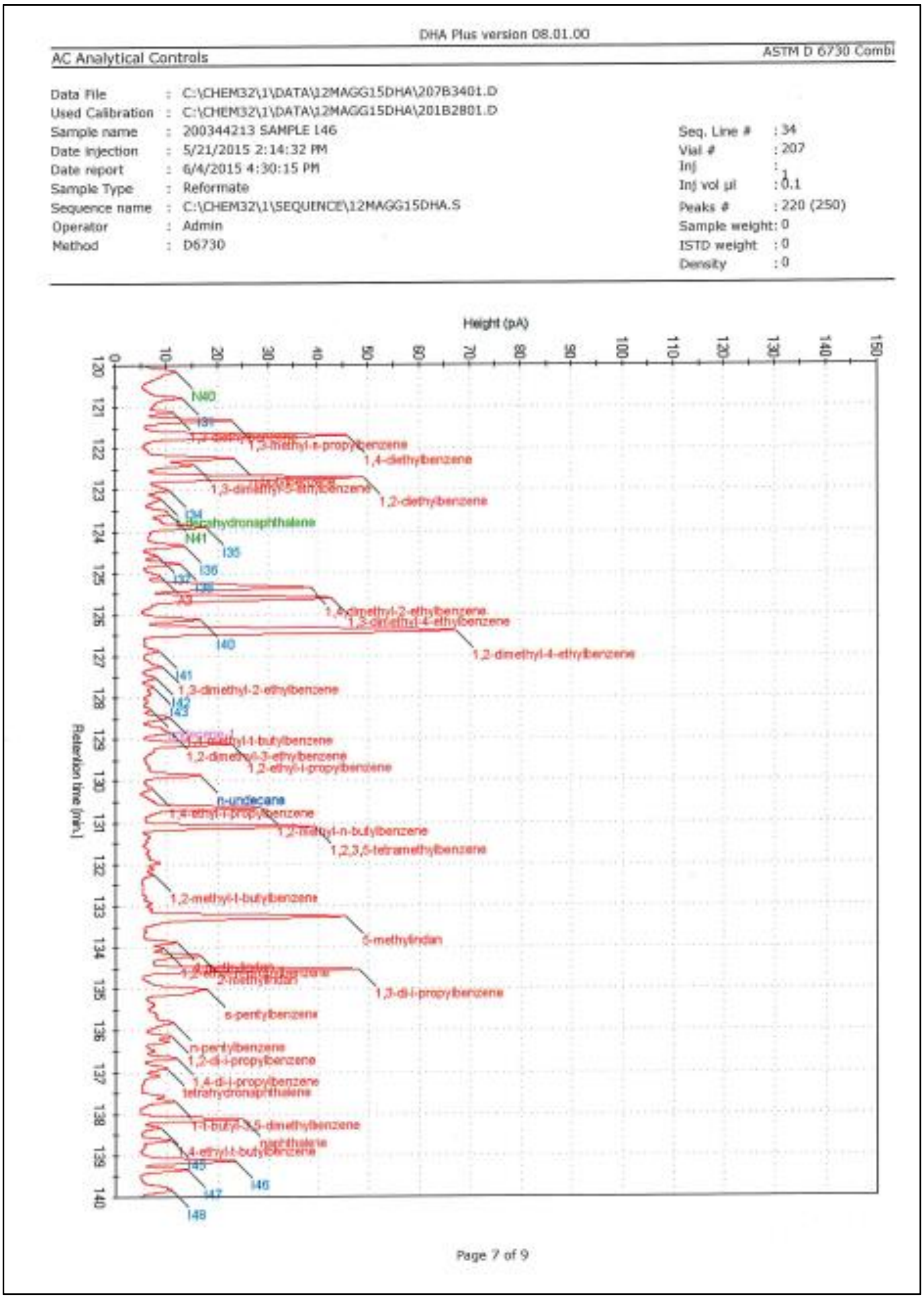
AC Analytical Controls

ASTM D 6730 Combi

Data File	: C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D		
Used Calibration	: C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D		
Sample name	: 200344213 SAMPLE 146	Seq. Line #	: 34
Date injection	: 5/21/2015 2:14:32 PM	Vial #	: 207
		Inj	: 1
Date report	: 6/4/2015 4:30:15 PM	Inj vol µl	: 0.1
Sample Type	: Reformate		
Sequence name	: C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S	Peaks #	: 220 (250)
Operator	: Admin	Sample weight	: 0
Method	: D6730	ISTD weight	: 0
		Density	: 0



Page 6 of 9



DHA Plus version 08.01.00

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight: 0
ISTD weight : 0
Density : 0

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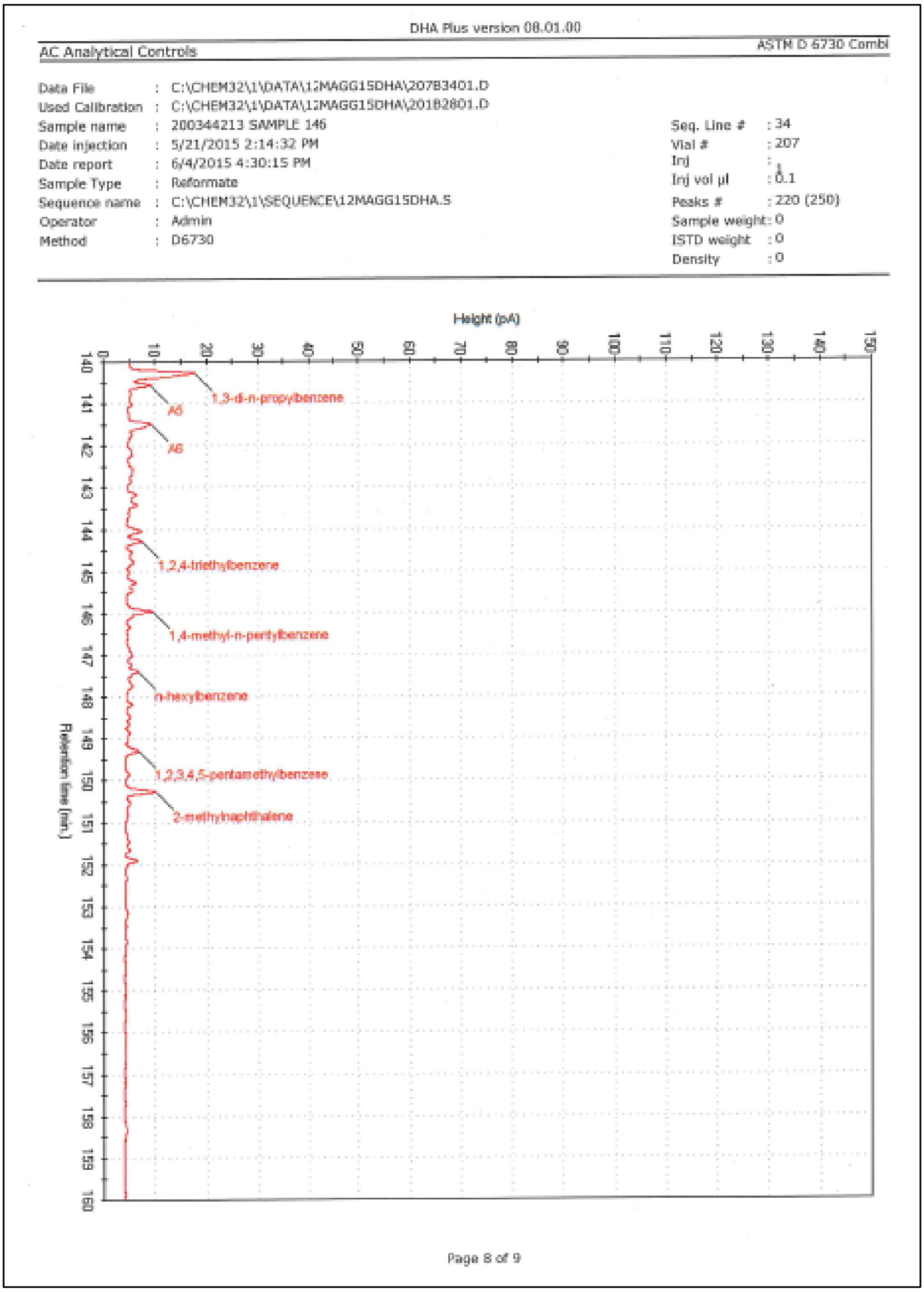

DHA Plus version 08.01.00

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:15 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)
Sample weight : 0
ISTD weight : 0
Density : 0

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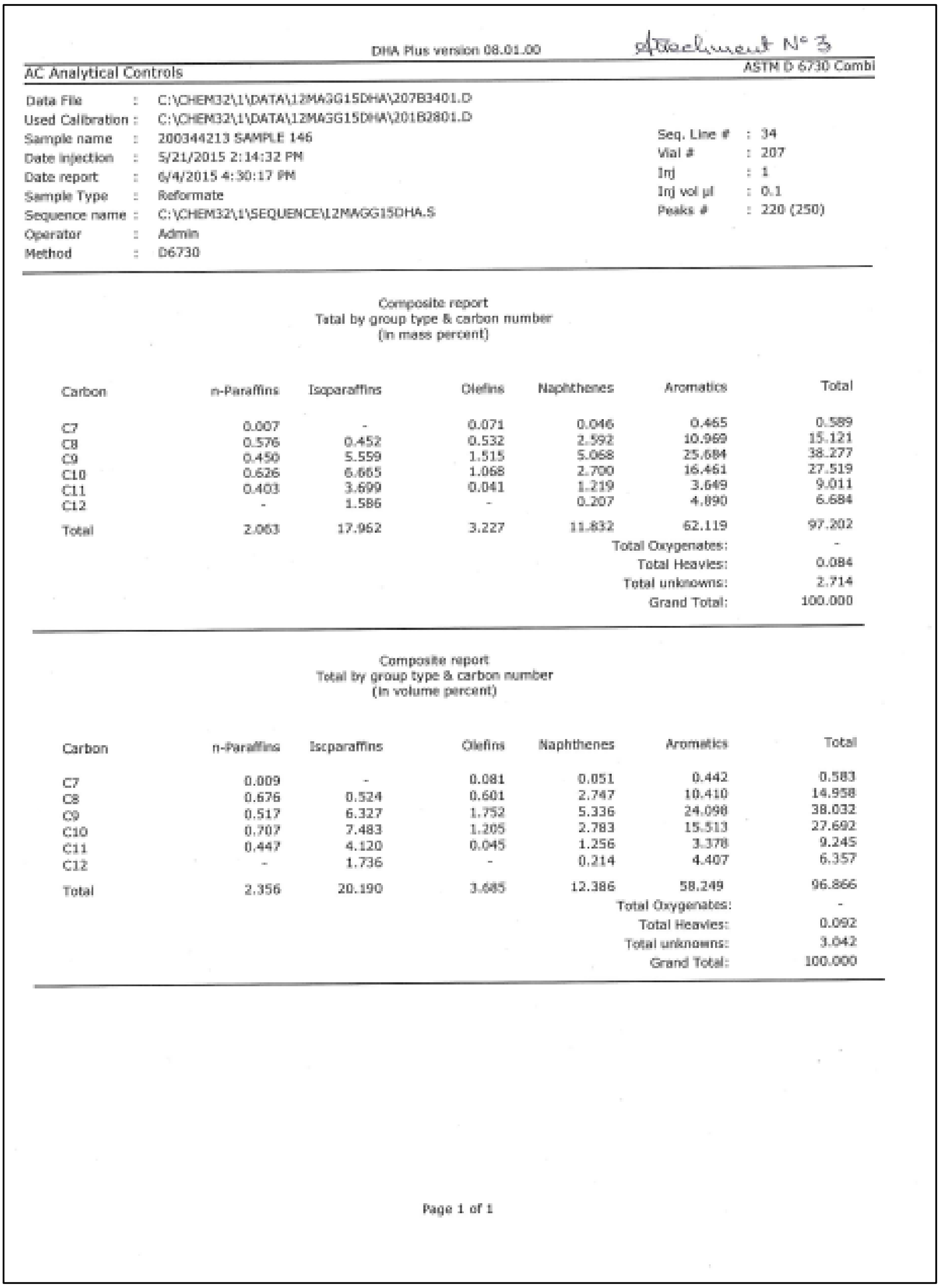

DHA Plus version 08.01.00

Attachment N° 3

AC Analytical Controls

ASTM D 6730 Combi

Data File : C:\CHEM32\1\DATA\12MAGG15DHA\207B3401.D
Used Calibration : C:\CHEM32\1\DATA\12MAGG15DHA\201B2801.D
Sample name : 200344213 SAMPLE 146
Date injection : 5/21/2015 2:14:32 PM
Date report : 6/4/2015 4:30:17 PM
Sample Type : Reformate
Sequence name : C:\CHEM32\1\SEQUENCE\12MAGG15DHA.S
Operator : Admin
Method : D6730

Seq. Line # : 34
Vial # : 207
Inj : 1
Inj vol µl : 0.1
Peaks # : 220 (250)

Composite report
Total by group type & carbon number
(in mass percent)

Carbon	n-Paraffins	Isoparaffins	Olefins	Naphthenes	Aromatics	Total
C7	0.007	-	0.071	0.046	0.465	0.589
C8	0.576	0.452	0.532	2.592	10.969	15.121
C9	0.450	5.559	1.515	5.068	25.684	38.277
C10	0.626	6.665	1.068	2.700	16.461	27.519
C11	0.403	3.699	0.041	1.219	3.649	9.011
C12	-	1.586	-	0.207	4.890	6.684
Total	2.063	17.962	3.227	11.832	62.119	97.202
					Total Oxygenates:	-
					Total Heavies:	0.084
					Total unknowns:	2.714
					Grand Total:	100.000

Composite report
Total by group type & carbon number
(in volume percent)

Carbon	n-Paraffins	Isoparaffins	Olefins	Naphthenes	Aromatics	Total
C7	0.009	-	0.081	0.051	0.442	0.583
C8	0.676	0.524	0.601	2.747	10.410	14.958
C9	0.517	6.327	1.752	5.336	24.098	38.032
C10	0.707	7.483	1.205	2.783	15.513	27.692
C11	0.447	4.120	0.045	1.256	3.378	9.245
C12	-	1.736	-	0.214	4.407	6.357
Total	2.356	20.190	3.685	12.386	58.249	96.866
					Total Oxygenates:	-
					Total Heavies:	0.092
					Total unknowns:	3.042
					Grand Total:	100.000

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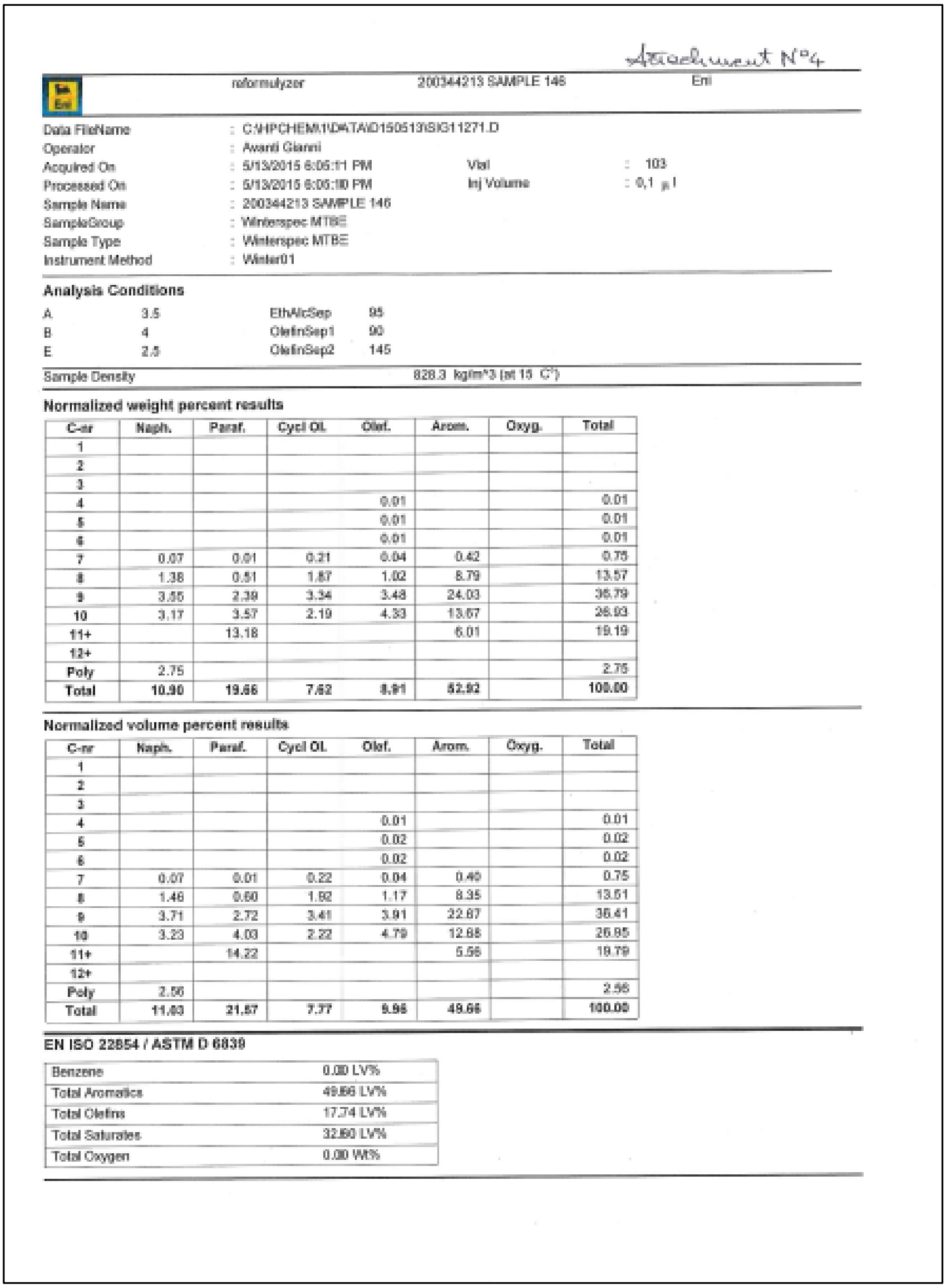


Attachment N°4

reformulyzer 200344213 SAMPLE 146 Eni

Data FileName : C:\HPCHEM\1\DATA\D150513\SIG11271.D
Operator : Avanti Gianni
Acquired On : 5/13/2015 6:05:11 PM Vial : 103
Processed On : 5/13/2015 6:05:18 PM Inj Volume : 0,1 µl
Sample Name : 200344213 SAMPLE 146
SampleGroup : Winterspec MTBE
Sample Type : Winterspec MTBE
Instrument Method : Winter01

Analysis Conditions

A	3.5	EthAlcSep	95
B	4	OlefinSep1	90
E	2.5	OlefinSep2	145

Sample Density 828.3 kg/m^3 (at 15 C°)

Normalized weight percent results

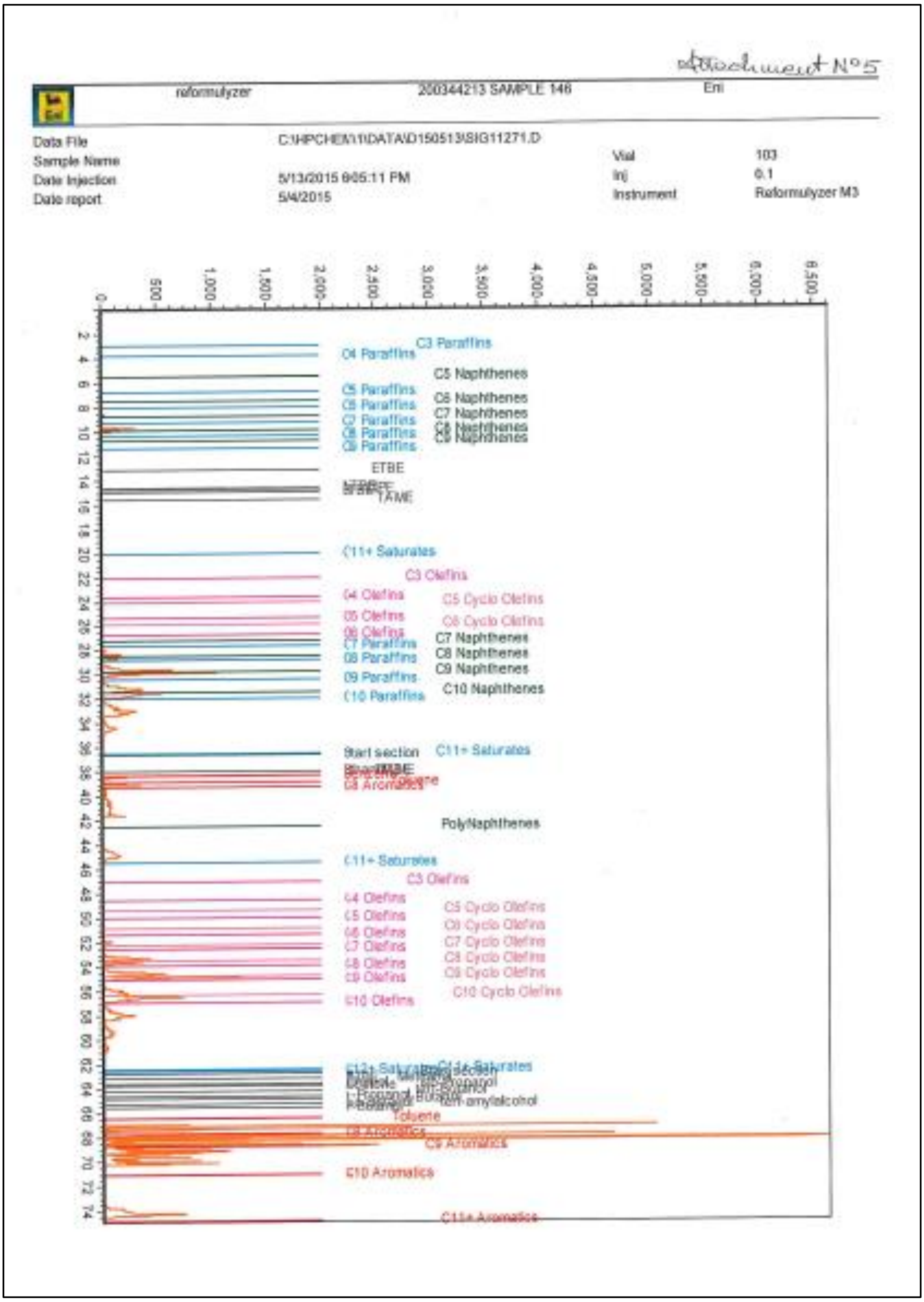
C-nr	Naph.	Paraf.	Cycl Ol.	Olef.	Arom.	Oxyg.	Total
1							
2							
3							
4				0.01			0.01
5				0.01			0.01
6				0.01			0.01
7	0.07	0.01	0.21	0.04	0.42		0.75
8	1.38	0.51	1.87	1.02	8.79		13.57
9	3.55	2.39	3.34	3.48	24.03		36.79
10	3.17	3.57	2.19	4.33	13.67		26.93
11+		13.18			6.01		19.19
12+							
Poly	2.75						2.75
Total	**10.90**	**19.66**	**7.62**	**8.91**	**52.92**		**100.00**

Normalized volume percent results

C-nr	Naph.	Paraf.	Cycl Ol.	Olef.	Arom.	Oxyg.	Total
1							
2							
3							
4				0.01			0.01
5				0.02			0.02
6				0.02			0.02
7	0.07	0.01	0.22	0.04	0.40		0.75
8	1.46	0.60	1.92	1.17	8.35		13.51
9	3.71	2.72	3.41	3.91	22.67		36.41
10	3.23	4.03	2.22	4.79	12.68		26.95
11+		14.22			5.56		19.79
12+							
Poly	2.56						2.56
Total	**11.03**	**21.67**	**7.77**	**9.96**	**49.66**		**100.00**

EN ISO 22854 / ASTM D 6839

Benzene	0.00 LV%
Total Aromatics	49.66 LV%
Total Olefins	17.74 LV%
Total Saturates	32.80 LV%
Total Oxygen	0.00 Wt%



Attachment N°5

reformulyzer 200344213 SAMPLE 146 Eni

Data File C:\HPCHEM\1\DATA\D150513\SIG11271.D

Sample Name

Date Injection 5/13/2015 8:05:11 PM

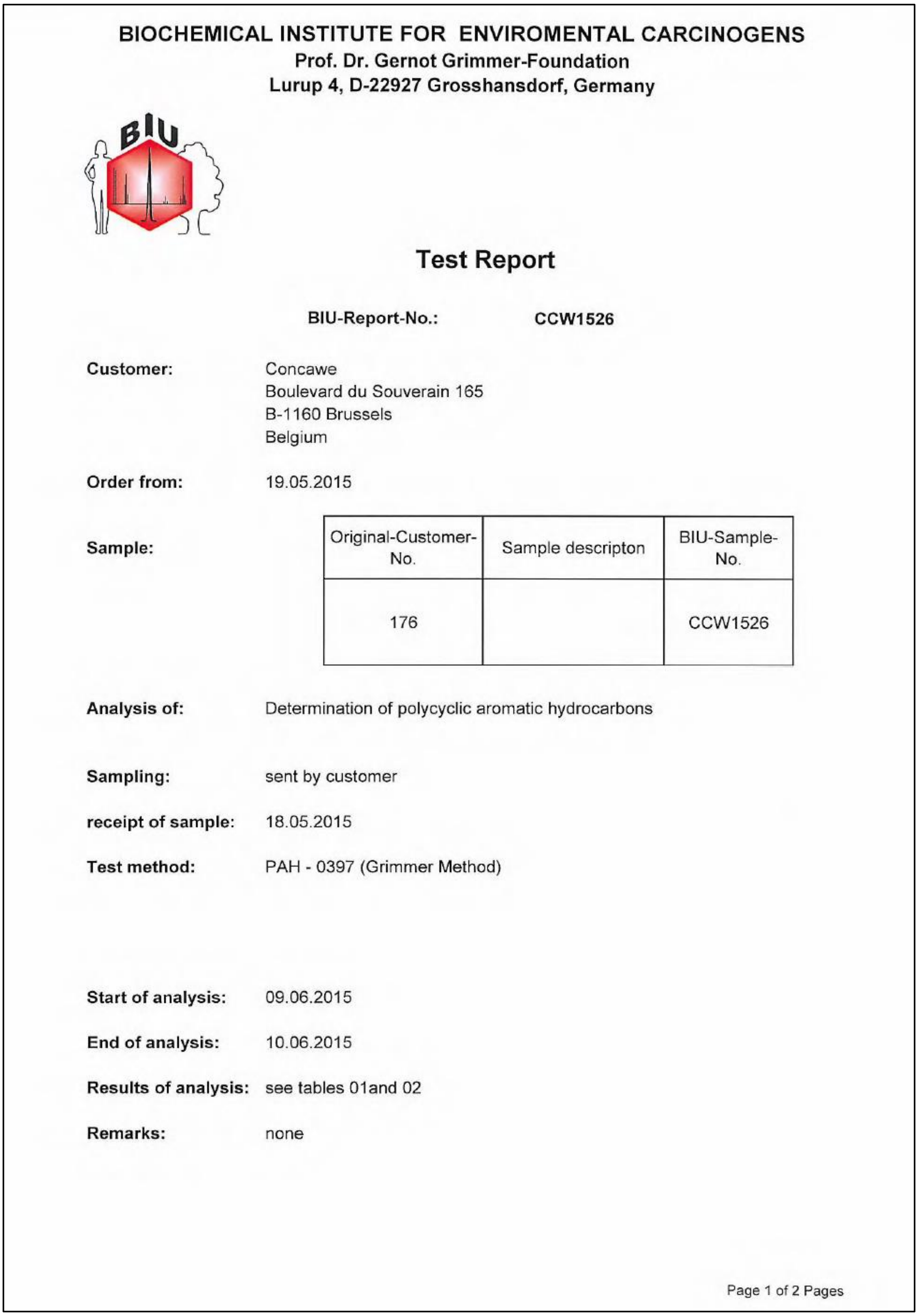
Date report 5/4/2015

Vial 103

Inj 0.1

Instrument Reformulyzer M3

APPENDIX 8 – EXAMPLE OF PAH REPORT (SAMPLE 176 - VHGO)



BIOCHEMICAL INSTITUTE FOR ENVIROMENTAL CARCINOGENS
Prof. Dr. Gernot Grimmer-Foundation
Lurup 4, D-22927 Grosshansdorf, Germany

Test Report

BIU-Report-No.: **CCW1526**

Customer:
Concawe
Boulevard du Souverain 165
B-1160 Brussels
Belgium

Order from: 19.05.2015

Sample:

Original-Customer-No.	Sample descripton	BIU-Sample-No.
176		CCW1526

Analysis of: Determination of polycyclic aromatic hydrocarbons

Sampling: sent by customer

receipt of sample: 18.05.2015

Test method: PAH - 0397 (Grimmer Method)

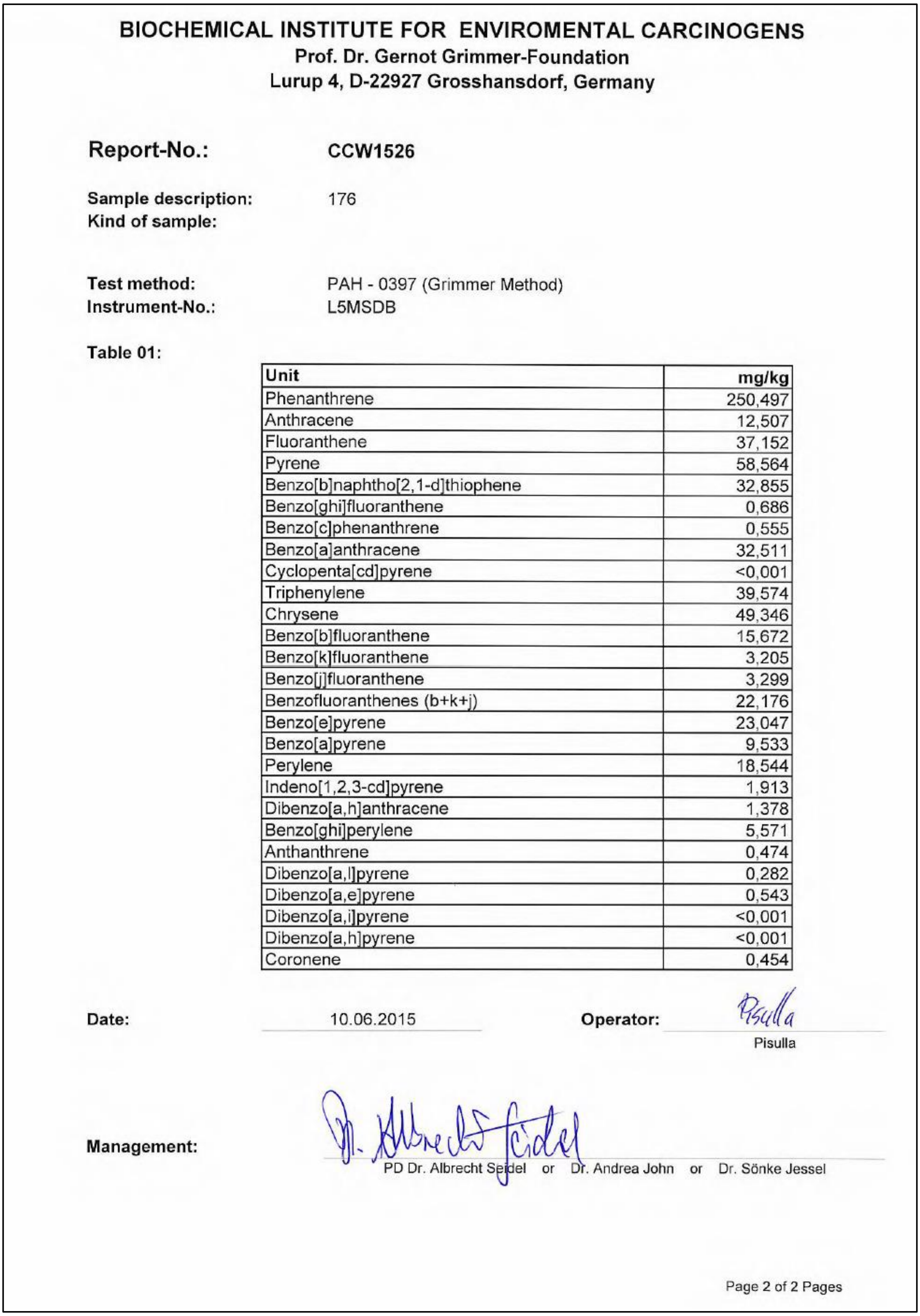
Start of analysis: 09.06.2015

End of analysis: 10.06.2015

Results of analysis: see tables 01and 02

Remarks: none

Page 1 of 2 Pages



BIOCHEMICAL INSTITUTE FOR ENVIROMENTAL CARCINOGENS
Prof. Dr. Gernot Grimmer-Foundation
Lurup 4, D-22927 Grosshansdorf, Germany

Report-No.: CCW1526

Sample description: 176
Kind of sample:

Test method: PAH - 0397 (Grimmer Method)
Instrument-No.: L5MSDB

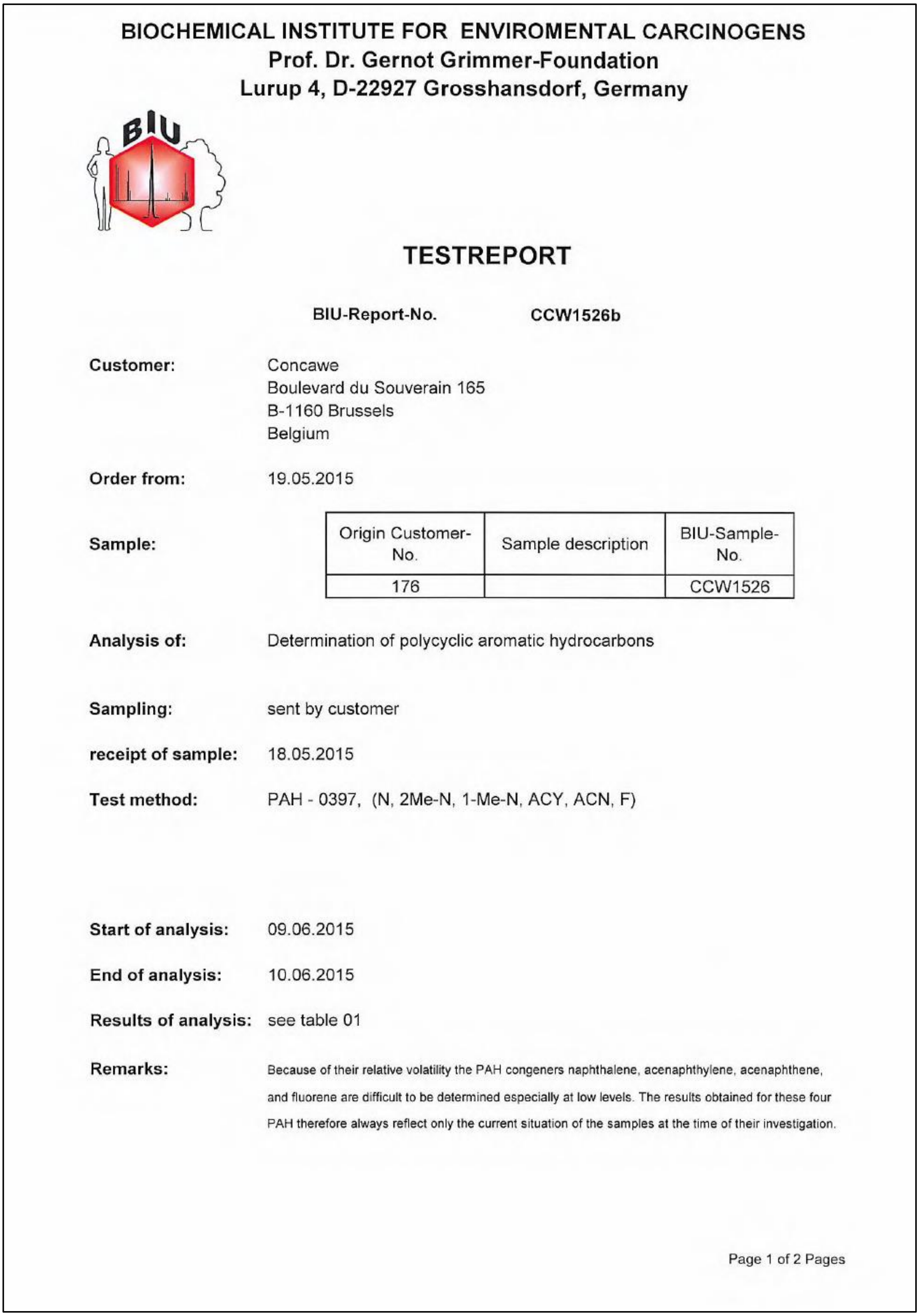
Table 01:

Unit	mg/kg
Phenanthrene	250,497
Anthracene	12,507
Fluoranthene	37,152
Pyrene	58,564
Benzo[b]naphtho[2,1-d]thiophene	32,855
Benzo[ghi]fluoranthene	0,686
Benzo[c]phenanthrene	0,555
Benzo[a]anthracene	32,511
Cyclopenta[cd]pyrene	<0,001
Triphenylene	39,574
Chrysene	49,346
Benzo[b]fluoranthene	15,672
Benzo[k]fluoranthene	3,205
Benzo[j]fluoranthene	3,299
Benzofluoranthenes (b+k+j)	22,176
Benzo[e]pyrene	23,047
Benzo[a]pyrene	9,533
Perylene	18,544
Indeno[1,2,3-cd]pyrene	1,913
Dibenzo[a,h]anthracene	1,378
Benzo[ghi]perylene	5,571
Anthanthrene	0,474
Dibenzo[a,l]pyrene	0,282
Dibenzo[a,e]pyrene	0,543
Dibenzo[a,i]pyrene	<0,001
Dibenzo[a,h]pyrene	<0,001
Coronene	0,454

Date: 10.06.2015 **Operator:** Pisulla

Management: PD Dr. Albrecht Seidel or Dr. Andrea John or Dr. Sönke Jessel

Page 2 of 2 Pages



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Prof. Dr. Gernot Grimmer-Foundation
Lurup 4, D-22927 Grosshansdorf, Germany

TESTREPORT

BIU-Report-No. **CCW1526b**

Customer:
Concawe
Boulevard du Souverain 165
B-1160 Brussels
Belgium

Order from: 19.05.2015

Sample:

Origin Customer-No.	Sample description	BIU-Sample-No.
176		CCW1526

Analysis of: Determination of polycyclic aromatic hydrocarbons

Sampling: sent by customer

receipt of sample: 18.05.2015

Test method: PAH - 0397, (N, 2Me-N, 1-Me-N, ACY, ACN, F)

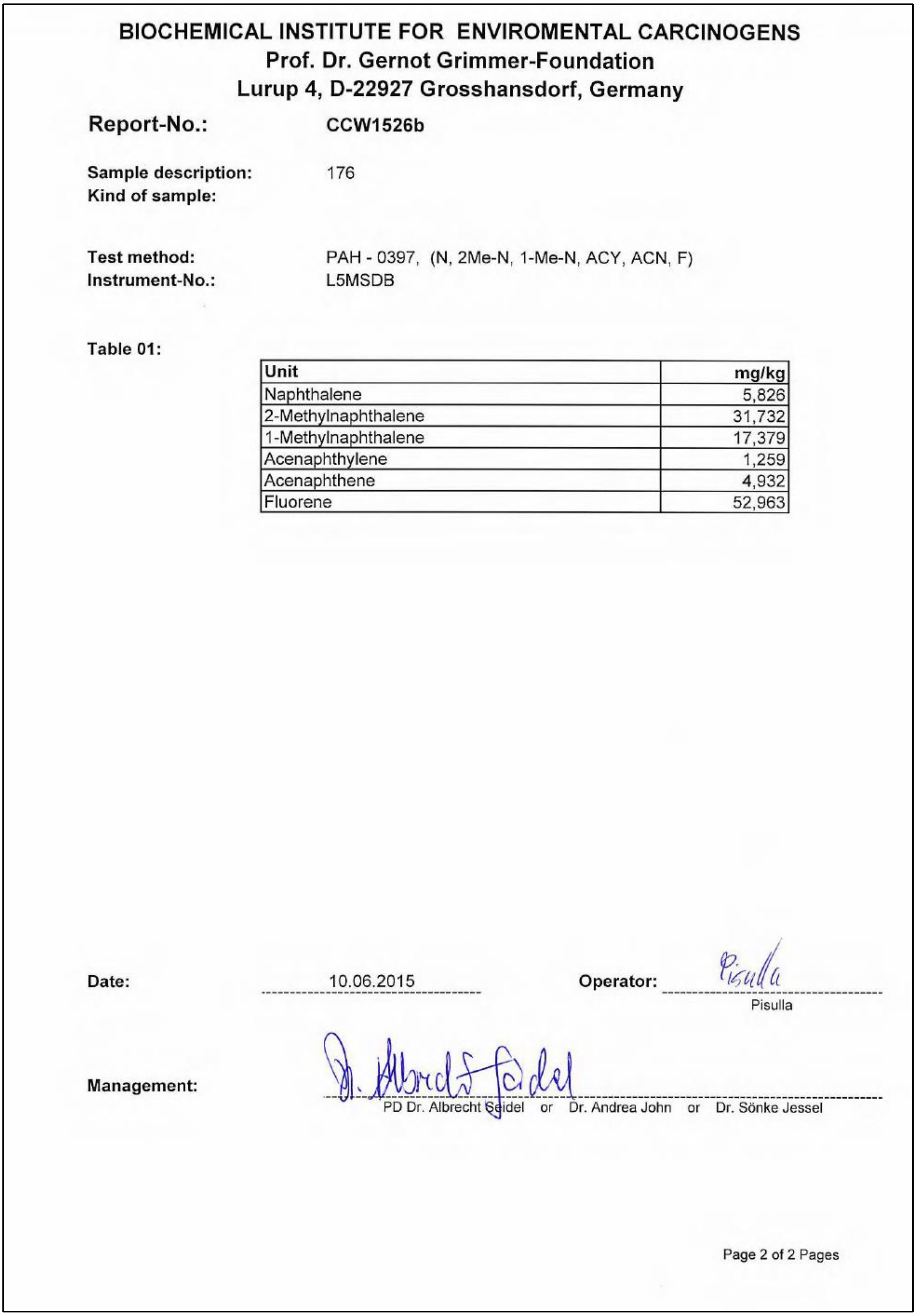
Start of analysis: 09.06.2015

End of analysis: 10.06.2015

Results of analysis: see table 01

Remarks: Because of their relative volatility the PAH congeners naphthalene, acenaphthylene, acenaphthene, and fluorene are difficult to be determined especially at low levels. The results obtained for these four PAH therefore always reflect only the current situation of the samples at the time of their investigation.

Page 1 of 2 Pages



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Prof. Dr. Gernot Grimmer-Foundation
Lurup 4, D-22927 Grosshansdorf, Germany

Report-No.: **CCW1526b**

Sample description: 176
Kind of sample:

Test method: PAH - 0397, (N, 2Me-N, 1-Me-N, ACY, ACN, F)
Instrument-No.: L5MSDB

Table 01:

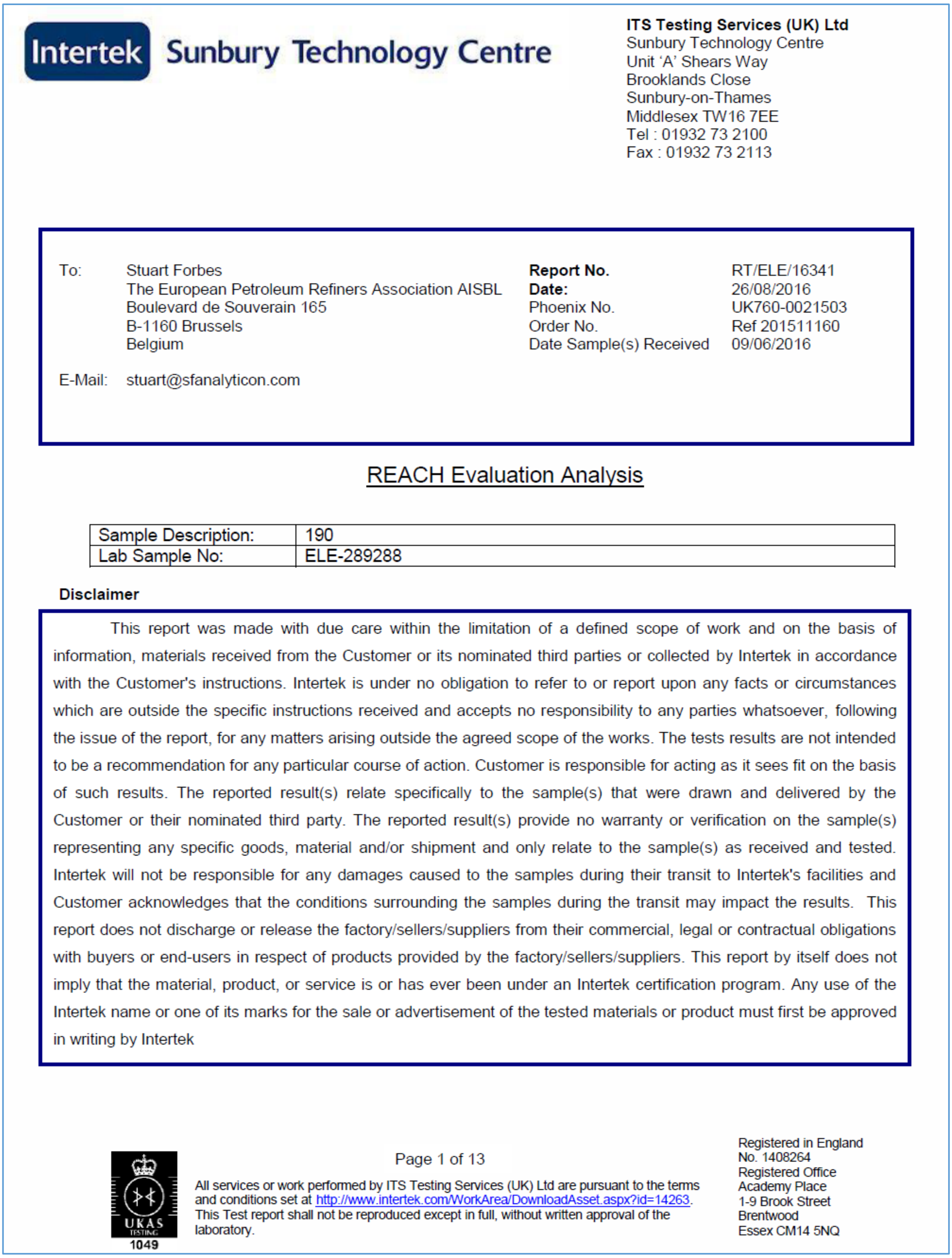
Unit	**mg/kg**
Naphthalene	5,826
2-Methylnaphthalene	31,732
1-Methylnaphthalene	17,379
Acenaphthylene	1,259
Acenaphthene	4,932
Fluorene	52,963

Date: 10.06.2015 **Operator:** Pisulla
Pisulla

Management: Dr. Albrecht Seidel
PD Dr. Albrecht Seidel or Dr. Andrea John or Dr. Sönke Jessel

Page 2 of 2 Pages

APPENDIX 9 – EXAMPLE OF ELEMENTAL ANALYSIS REPORT (SAMPLE 190 - BITUMEN)



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To: Stuart Forbes
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E-Mail: stuart@sfanalyticon.com

Report No. RT/ELE/16341
Date: 26/08/2016
Phoenix No. UK760-0021503
Order No. Ref 201511160
Date Sample(s) Received 09/06/2016

REACH Evaluation Analysis

Sample Description:	190
Lab Sample No:	ELE-289288

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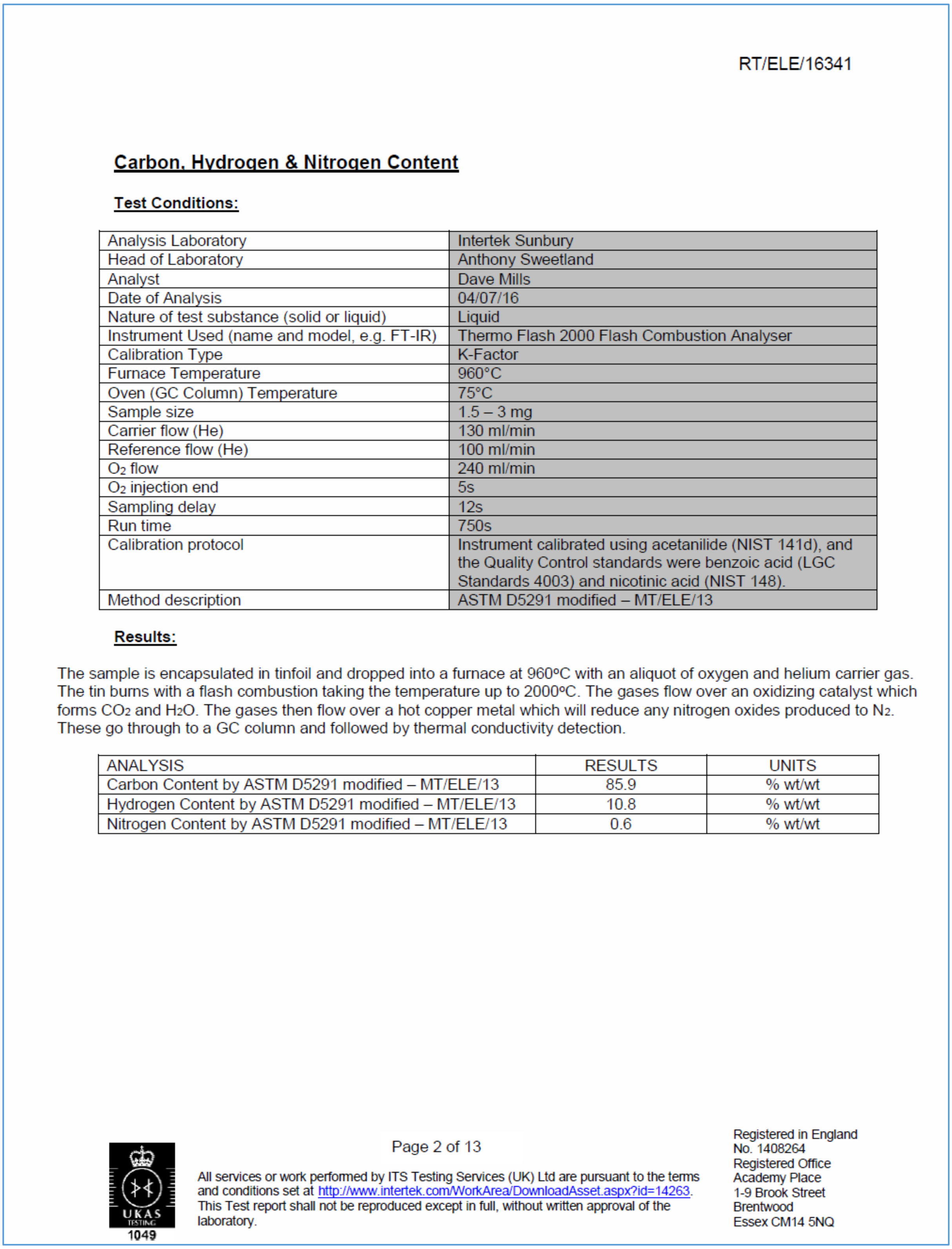


Carbon, Hydrogen & Nitrogen Content

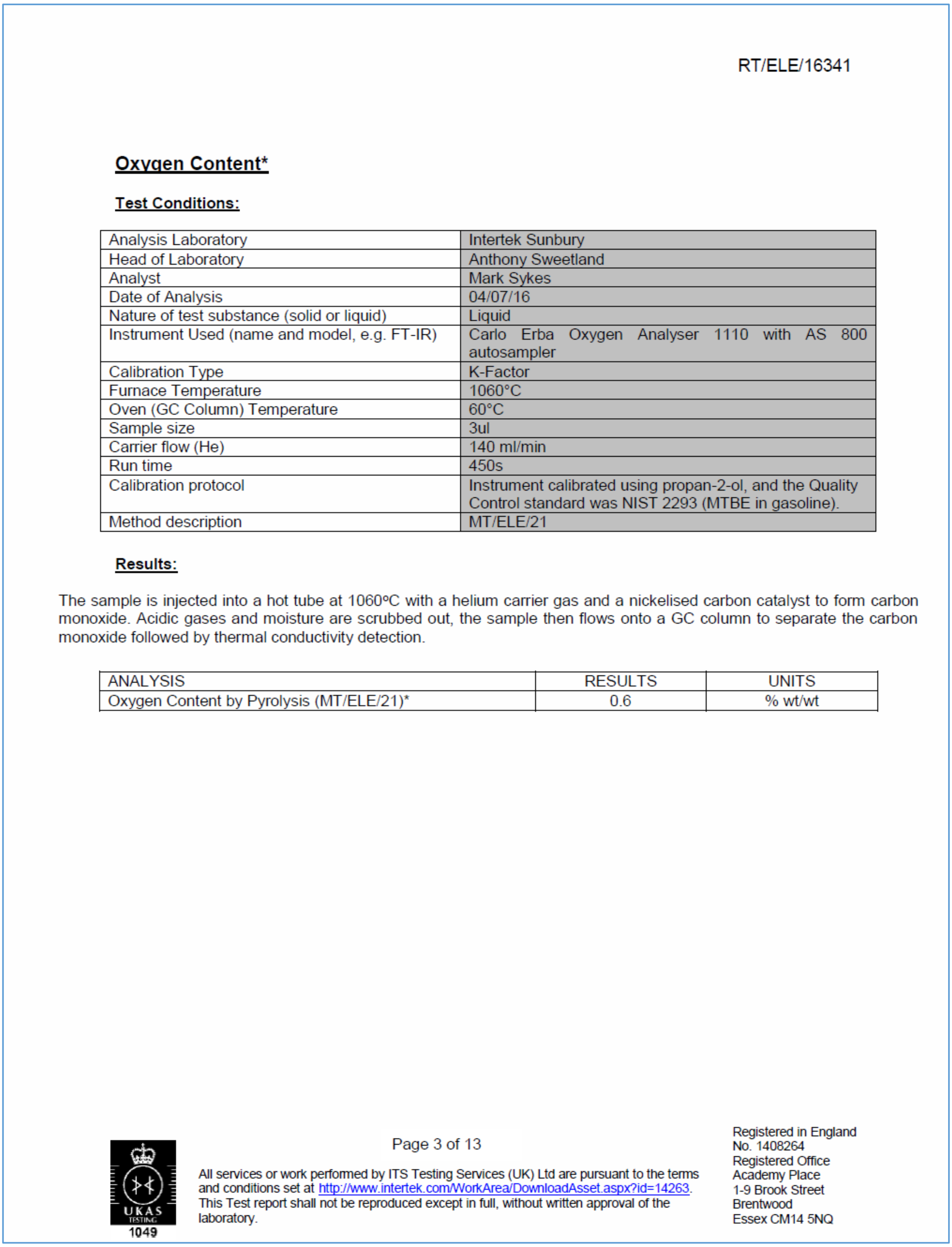
Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Dave Mills
Date of Analysis	04/07/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	Thermo Flash 2000 Flash Combustion Analyser
Calibration Type	K-Factor
Furnace Temperature	960°C
Oven (GC Column) Temperature	75°C
Sample size	1.5 – 3 mg
Carrier flow (He)	130 ml/min
Reference flow (He)	100 ml/min
O_2 flow	240 ml/min
O_2 injection end	5s
Sampling delay	12s
Run time	750s
Calibration protocol	Instrument calibrated using acetanilide (NIST 141d), and the Quality Control standards were benzoic acid (LGC Standards 4003) and nicotinic acid (NIST 148).
Method description	ASTM D5291 modified – MT/ELE/13

Results:

The sample is encapsulated in tinfoil and dropped into a furnace at 960ºC with an aliquot of oxygen and helium carrier gas. The tin burns with a flash combustion taking the temperature up to 2000ºC. The gases flow over an oxidizing catalyst which forms CO_2 and H_2O. The gases then flow over a hot copper metal which will reduce any nitrogen oxides produced to N_2. These go through to a GC column and followed by thermal conductivity detection.

ANALYSIS	RESULTS	UNITS
Carbon Content by ASTM D5291 modified – MT/ELE/13	85.9	% wt/wt
Hydrogen Content by ASTM D5291 modified – MT/ELE/13	10.8	% wt/wt
Nitrogen Content by ASTM D5291 modified – MT/ELE/13	0.6	% wt/wt



RT/ELE/16341

Oxygen Content*

Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Mark Sykes
Date of Analysis	04/07/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	Carlo Erba Oxygen Analyser 1110 with AS 800 autosampler
Calibration Type	K-Factor
Furnace Temperature	1060°C
Oven (GC Column) Temperature	60°C
Sample size	3ul
Carrier flow (He)	140 ml/min
Run time	450s
Calibration protocol	Instrument calibrated using propan-2-ol, and the Quality Control standard was NIST 2293 (MTBE in gasoline).
Method description	MT/ELE/21

Results:

The sample is injected into a hot tube at 1060ºC with a helium carrier gas and a nickelised carbon catalyst to form carbon monoxide. Acidic gases and moisture are scrubbed out, the sample then flows onto a GC column to separate the carbon monoxide followed by thermal conductivity detection.

ANALYSIS	RESULTS	UNITS
Oxygen Content by Pyrolysis (MT/ELE/21)*	0.6	% wt/wt

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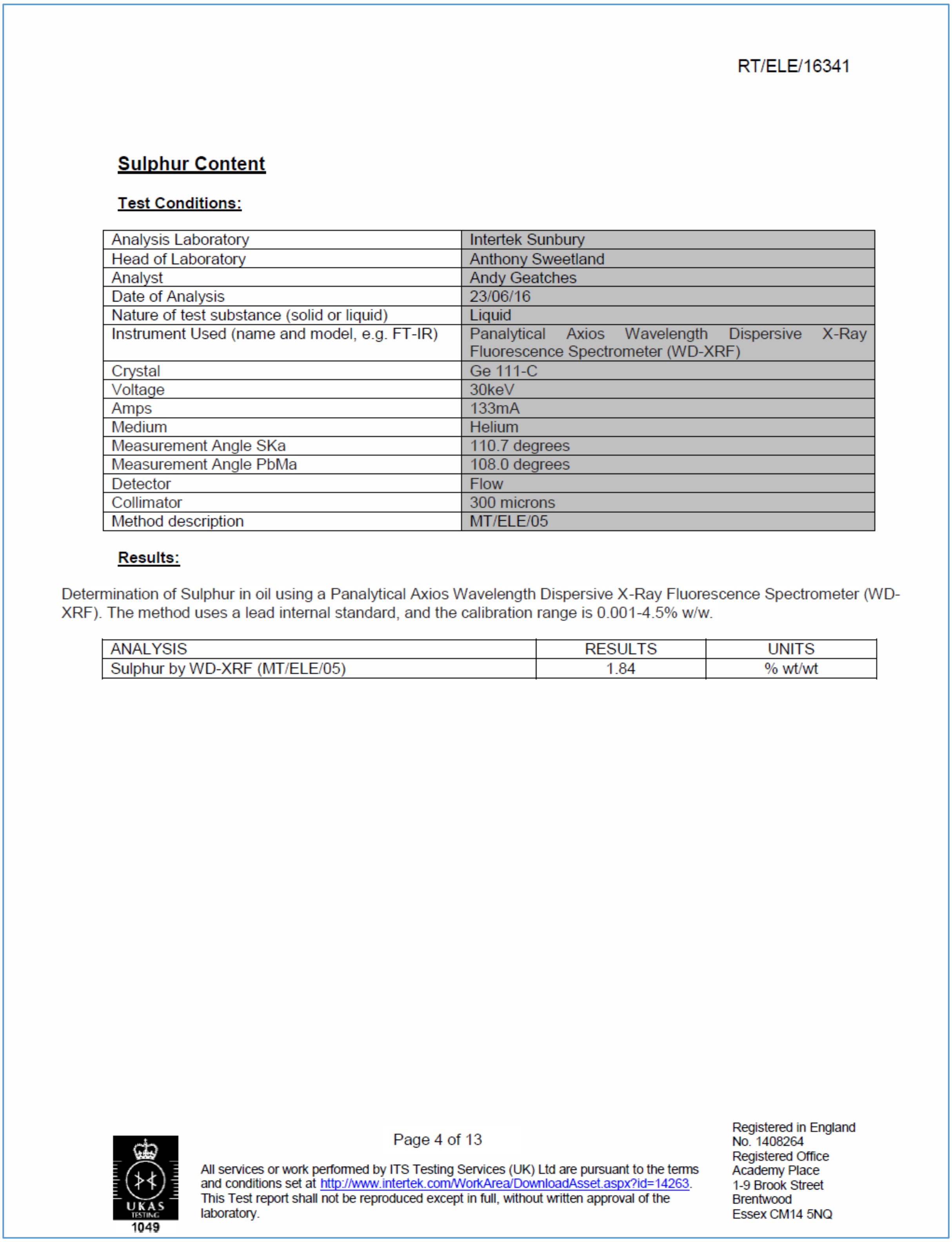

RT/ELE/16341

Sulphur Content

Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Andy Geatches
Date of Analysis	23/06/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	Panalytical Axios Wavelength Dispersive X-Ray Fluorescence Spectrometer (WD-XRF)
Crystal	Ge 111-C
Voltage	30keV
Amps	133mA
Medium	Helium
Measurement Angle SKa	110.7 degrees
Measurement Angle PbMa	108.0 degrees
Detector	Flow
Collimator	300 microns
Method description	MT/ELE/05

Results:

Determination of Sulphur in oil using a Panalytical Axios Wavelength Dispersive X-Ray Fluorescence Spectrometer (WD-XRF). The method uses a lead internal standard, and the calibration range is 0.001-4.5% w/w.

ANALYSIS	RESULTS	UNITS
Sulphur by WD-XRF (MT/ELE/05)	1.84	% wt/wt

UKAS TESTING 1049

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RT/ELE/16341

Elemental Content*

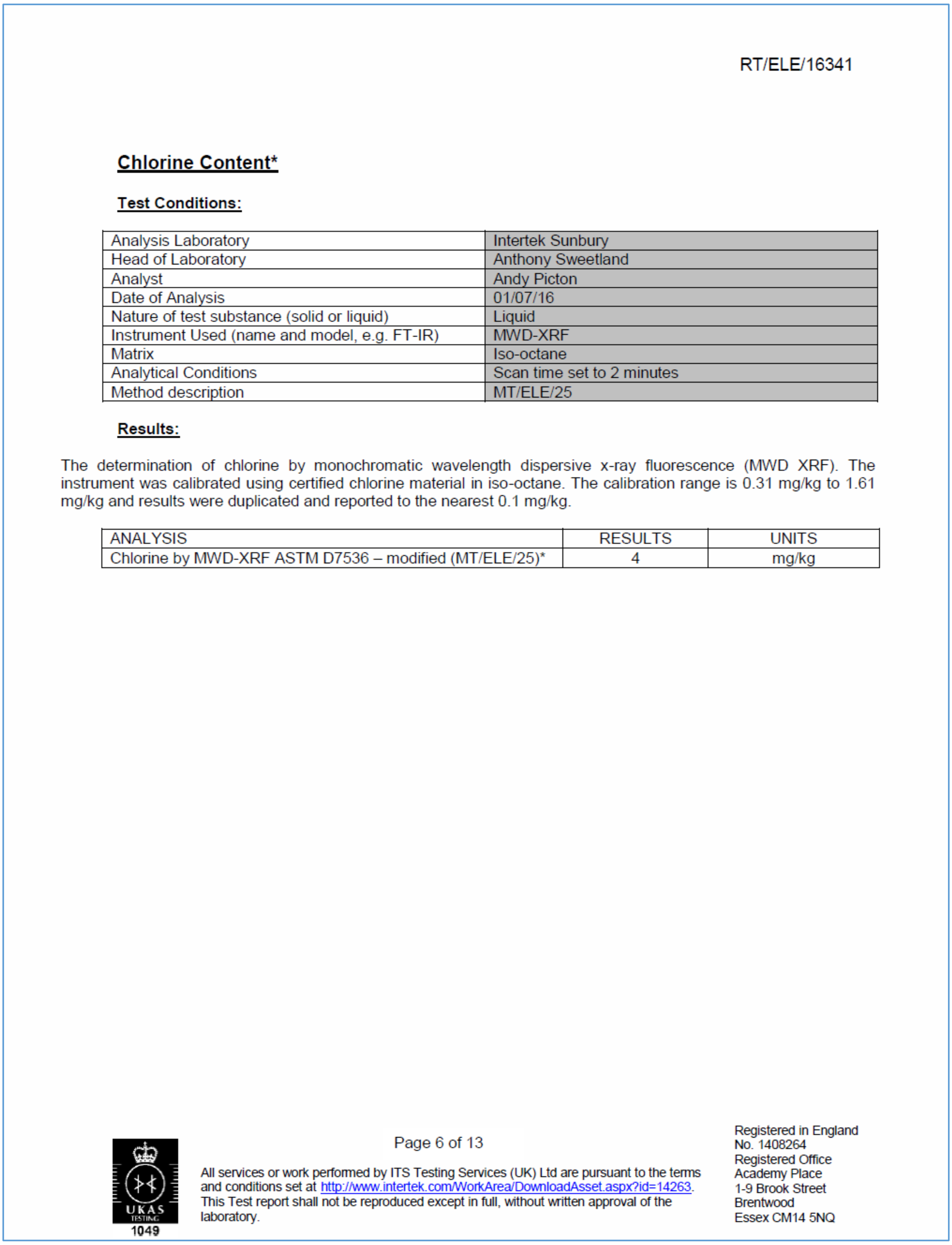
Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Tayyaba Rizvi
Date of Analysis	26/08/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	ICP-OES Optima 7300V
Plasma Gas Flow	20 L/min
Auxiliary Gas Flow	2 L/min
Nebuliser Gas Flow	0.32 L/min
Pump Flow Rate	1 ml/min
RF Power	1500 Watts
Method description	D5185mod (MT/ELE/01)

Results:

This method for the determination of additive elements, wear metals and contaminant elements using Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES). The sample is diluted in white spirit/xylene containing 2mg/L Yttrium internal standard. Solutions are introduced to the ICP instrument, and then aspirated into the plasma. The intensity of the resultant emitted light is measured at the following characteristic wavelengths. The calibration range is 1-900 mg/kg for all elements except for nickel, phosphorus and lead, where the calibration range is 1.5-900 mg/kg.

ANALYSIS	RESULTS	UNITS
Arsenic by ICP-OES (MT/ELE/01mod)*	<1	mg/kg
Cadmium by ICP-OES (MT/ELE/01mod)*	<1	mg/kg
Cobalt by ICP-OES (MT/ELE/01mod)*	<5	mg/kg
Copper by ICP-OES (MT/ELE/01)*	<1	mg/kg
Iron by ICP-OES (MT/ELE/01)*	9	mg/kg
Molybdenum by ICP-OES (MT/ELE/01)*	<1	mg/kg
Nickel by ICP-OES (MT/ELE/01)*	43	mg/kg
Phosphorus by ICP-OES (MT/ELE/01)*	<14	mg/kg
Lead by ICP-OES (MT/ELE/01)*	<6	mg/kg
Vanadium by ICP-OES (MT/ELE/01)*	124	mg/kg
Zinc by ICP-OES (MT/ELE/01)*	1	mg/kg



Chlorine Content*

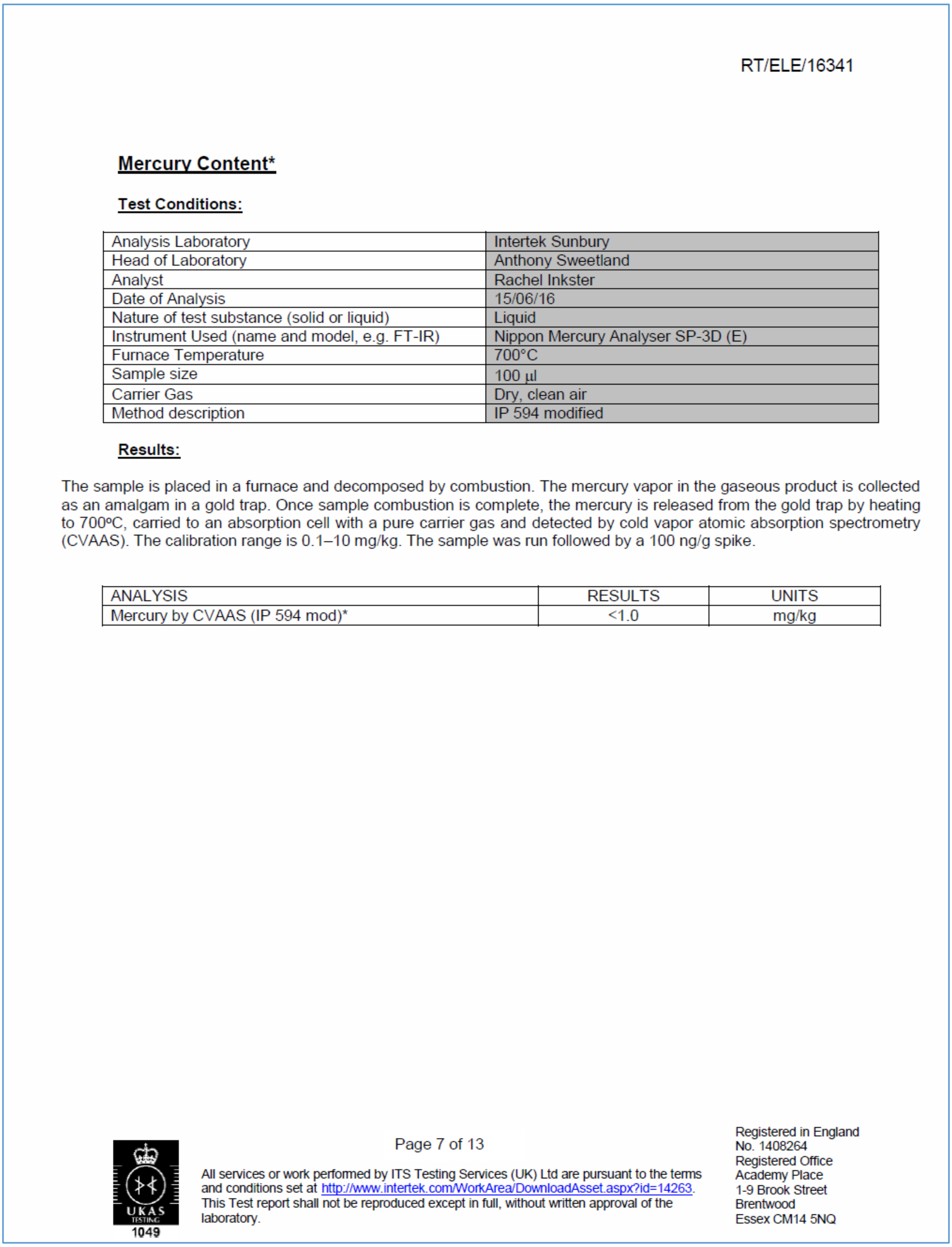
Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Andy Picton
Date of Analysis	01/07/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	MWD-XRF
Matrix	Iso-octane
Analytical Conditions	Scan time set to 2 minutes
Method description	MT/ELE/25

Results:

The determination of chlorine by monochromatic wavelength dispersive x-ray fluorescence (MWD XRF). The instrument was calibrated using certified chlorine material in iso-octane. The calibration range is 0.31 mg/kg to 1.61 mg/kg and results were duplicated and reported to the nearest 0.1 mg/kg.

ANALYSIS	RESULTS	UNITS
Chlorine by MWD-XRF ASTM D7536 – modified (MT/ELE/25)*	4	mg/kg



Mercury Content*

Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Rachel Inkster
Date of Analysis	15/06/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	Nippon Mercury Analyser SP-3D (E)
Furnace Temperature	700°C
Sample size	100 µl
Carrier Gas	Dry, clean air
Method description	IP 594 modified

Results:

The sample is placed in a furnace and decomposed by combustion. The mercury vapor in the gaseous product is collected as an amalgam in a gold trap. Once sample combustion is complete, the mercury is released from the gold trap by heating to 700ºC, carried to an absorption cell with a pure carrier gas and detected by cold vapor atomic absorption spectrometry (CVAAS). The calibration range is 0.1–10 mg/kg. The sample was run followed by a 100 ng/g spike.

ANALYSIS	RESULTS	UNITS
Mercury by CVAAS (IP 594 mod)*	<1.0	mg/kg

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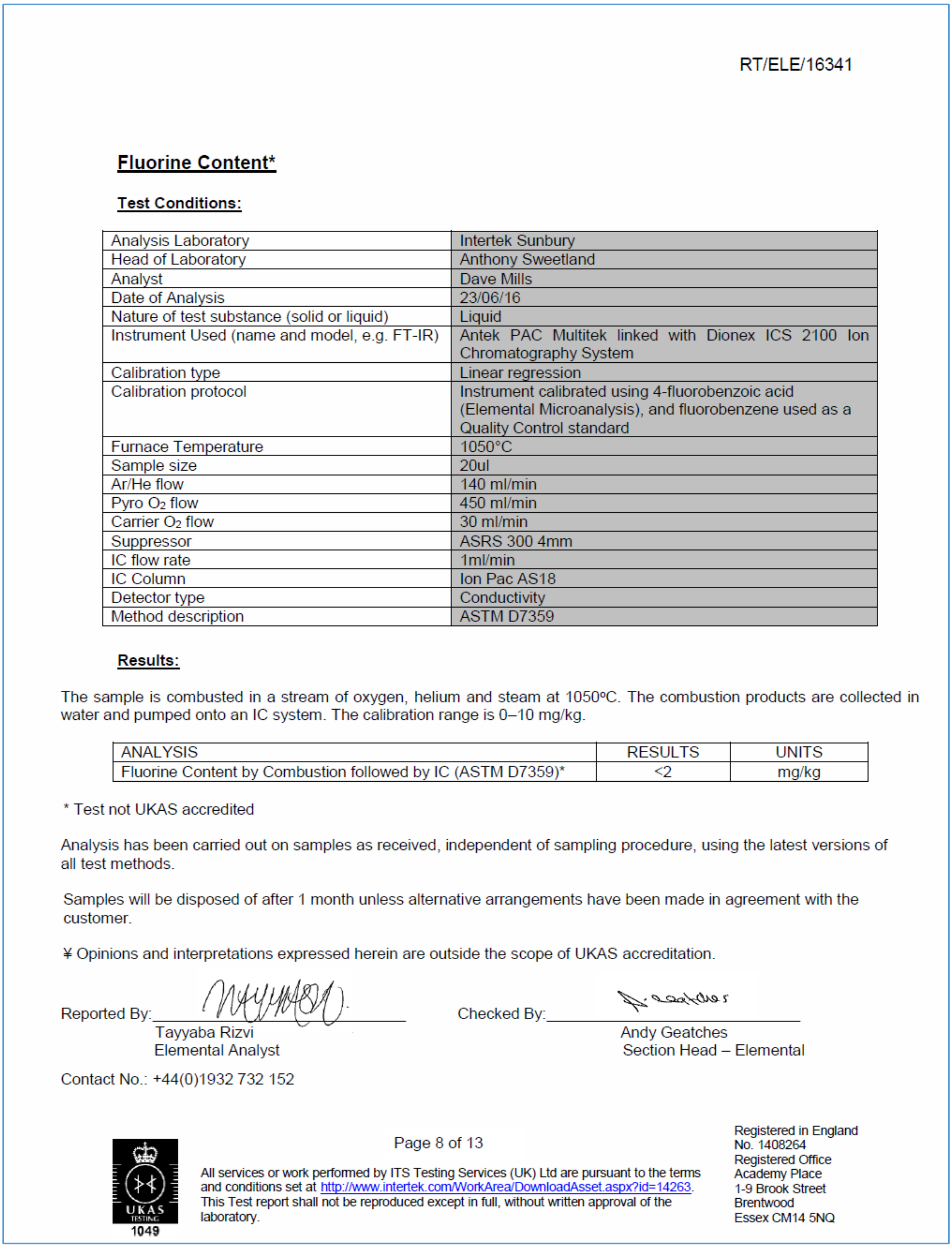

RT/ELE/16341

Fluorine Content*

Test Conditions:

Analysis Laboratory	Intertek Sunbury
Head of Laboratory	Anthony Sweetland
Analyst	Dave Mills
Date of Analysis	23/06/16
Nature of test substance (solid or liquid)	Liquid
Instrument Used (name and model, e.g. FT-IR)	Antek PAC Multitek linked with Dionex ICS 2100 Ion Chromatography System
Calibration type	Linear regression
Calibration protocol	Instrument calibrated using 4-fluorobenzoic acid (Elemental Microanalysis), and fluorobenzene used as a Quality Control standard
Furnace Temperature	1050°C
Sample size	20ul
Ar/He flow	140 ml/min
Pyro O_2 flow	450 ml/min
Carrier O_2 flow	30 ml/min
Suppressor	ASRS 300 4mm
IC flow rate	1ml/min
IC Column	Ion Pac AS18
Detector type	Conductivity
Method description	ASTM D7359

Results:

The sample is combusted in a stream of oxygen, helium and steam at 1050ºC. The combustion products are collected in water and pumped onto an IC system. The calibration range is 0–10 mg/kg.

ANALYSIS	RESULTS	UNITS
Fluorine Content by Combustion followed by IC (ASTM D7359)*	<2	mg/kg

* Test not UKAS accredited

Analysis has been carried out on samples as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

¥ Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Reported By:____________________
Tayyaba Rizvi
Elemental Analyst

Checked By:____________________
Andy Geatches
Section Head – Elemental

Contact No.: +44(0)1932 732 152

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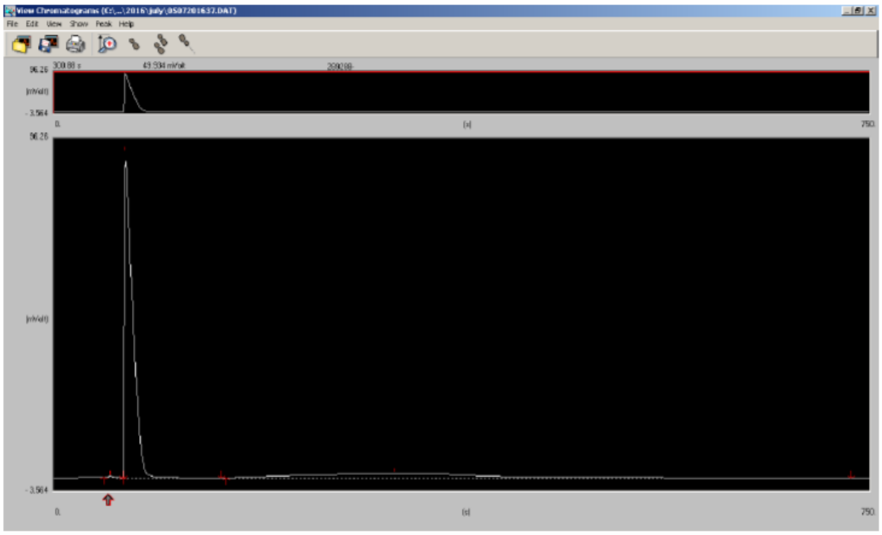
Figure 1 – CHN Spectra of 190



View Chromatograms (C:\...\2016\july\0507201637.DAT)

Figure 2 – Oxygen Spectra of 190

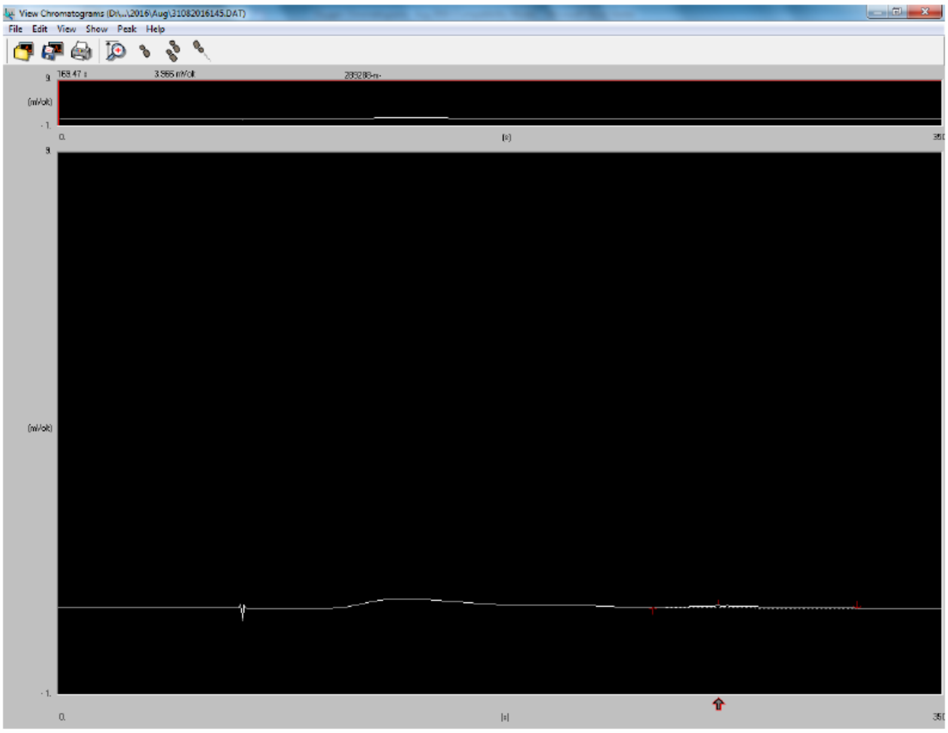
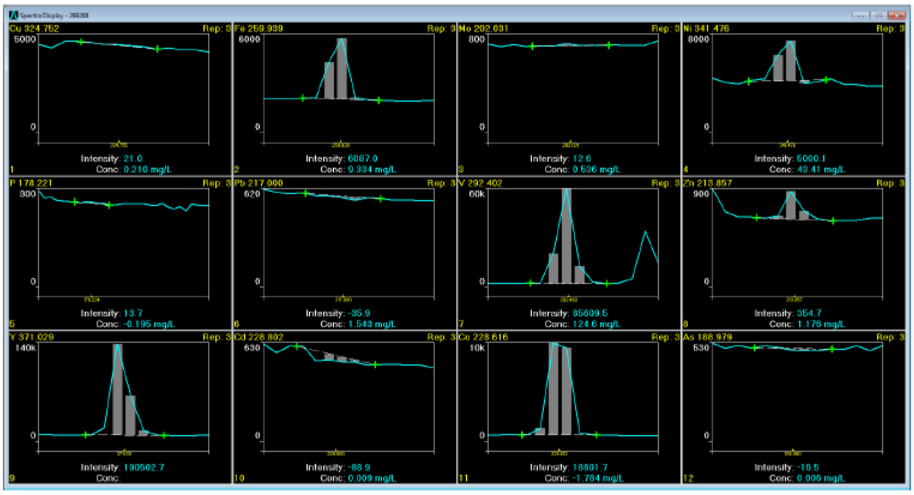


Figure 3 – Elemental Spectra of 190



1 Intensity: 21.0
Conc: 0.210 mg/L

2 Intensity: 6087.0
Conc: 0.334 mg/L

3 Intensity: 12.6
Conc: 0.536 mg/L

4 Intensity: 5000.1
Conc: 43.41 mg/L

5 Intensity: 13.7
Conc: -0.195 mg/L

6 Intensity: -35.9
Conc: 1.543 mg/L

7 Intensity: 85609.5
Conc: 124.6 mg/L

8 Intensity: 354.7
Conc: 1.176 mg/L

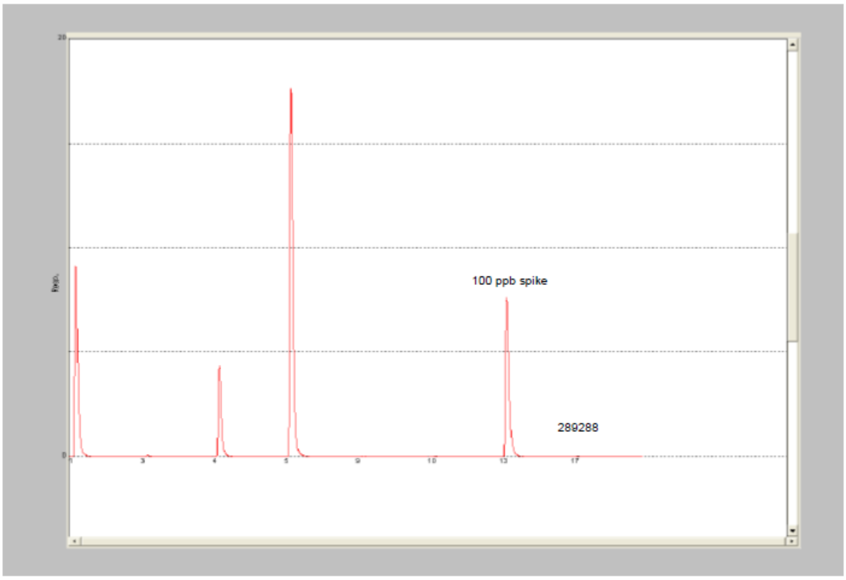
9 Intensity: 190502.7
Conc:

10 Intensity: -88.9
Conc: 0.009 mg/L

11 Intensity: 18801.7
Conc: -1.784 mg/L

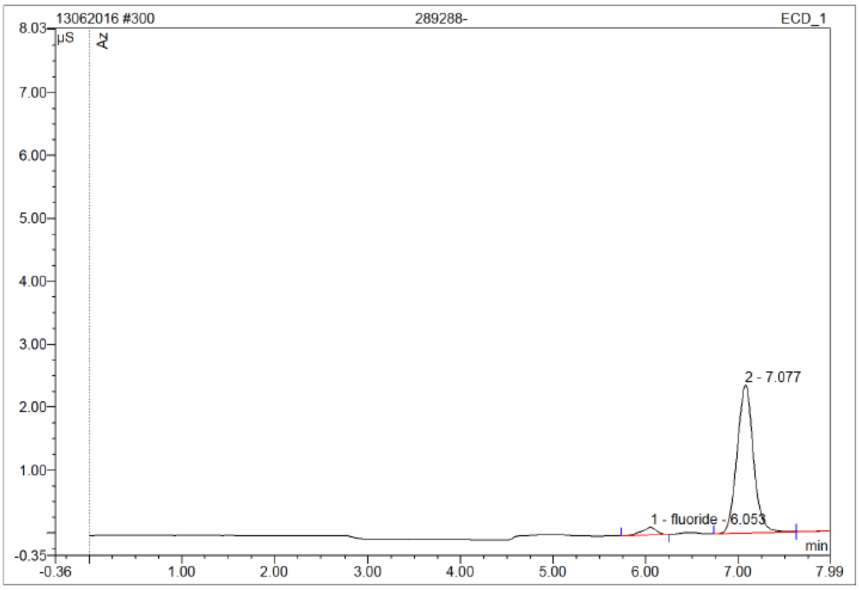
12 Intensity: -16.5
Conc: 0.006 mg/L

Figure 4 – Mercury Spectra of 190

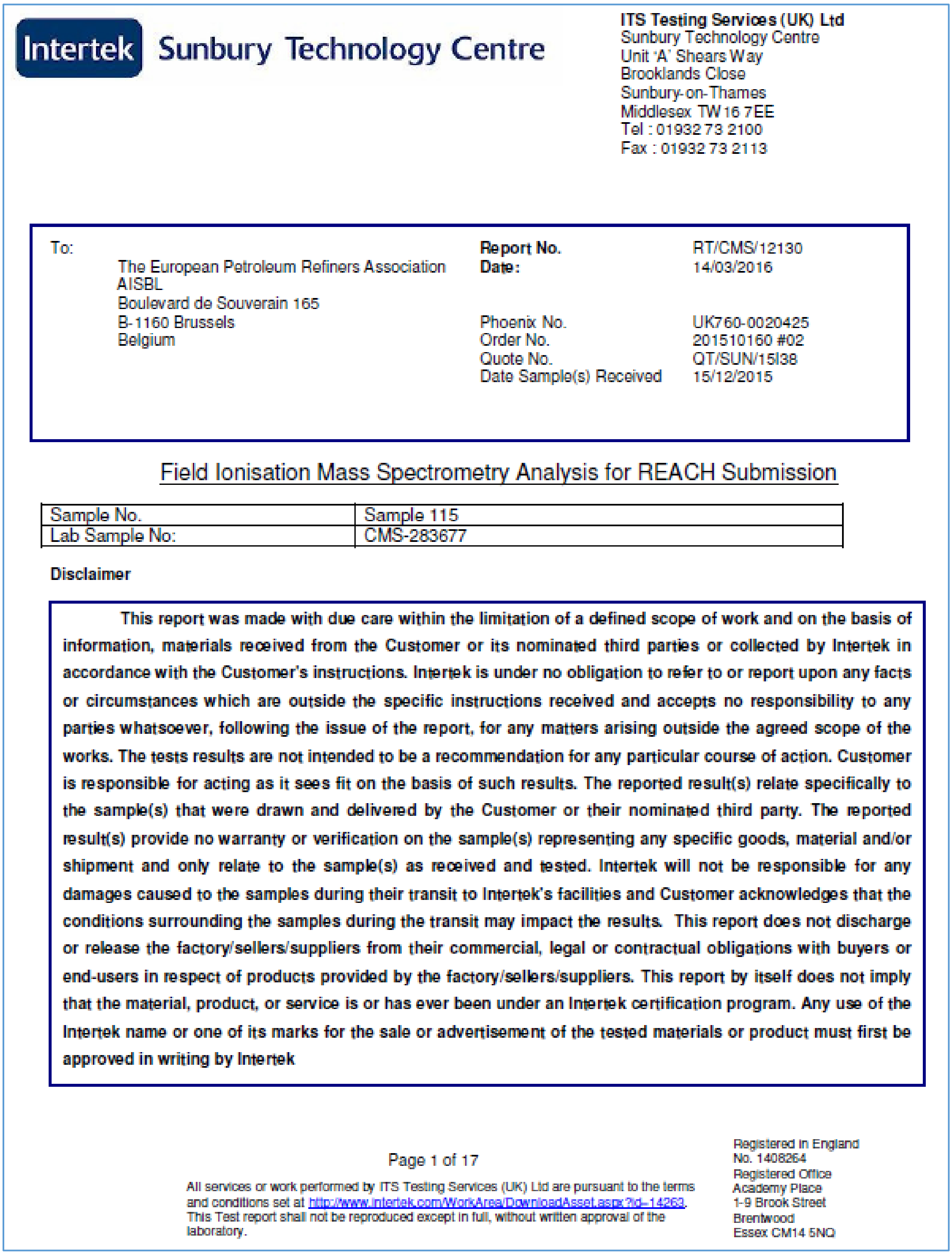


RT/ELE/16341

Figure 5 – Fluorine Spectra of 190



APPENDIX 10 – EXAMPLE OF FIMS REPORT (SAMPLE 115 - OLBO)



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Tel : 01932 73 2100
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To:
The European Petroleum Refiners Association AISBL
Boulevard de Souverain 165
B-1160 Brussels
Belgium

Report No.	RT/CMS/12130
Date:	14/03/2016
Phoenix No.	UK760-0020425
Order No.	201510160 #02
Quote No.	QT/SUN/15I38
Date Sample(s) Received	15/12/2015

Field Ionisation Mass Spectrometry Analysis for REACH Submission

Sample No.	Sample 115
Lab Sample No:	CMS-283677

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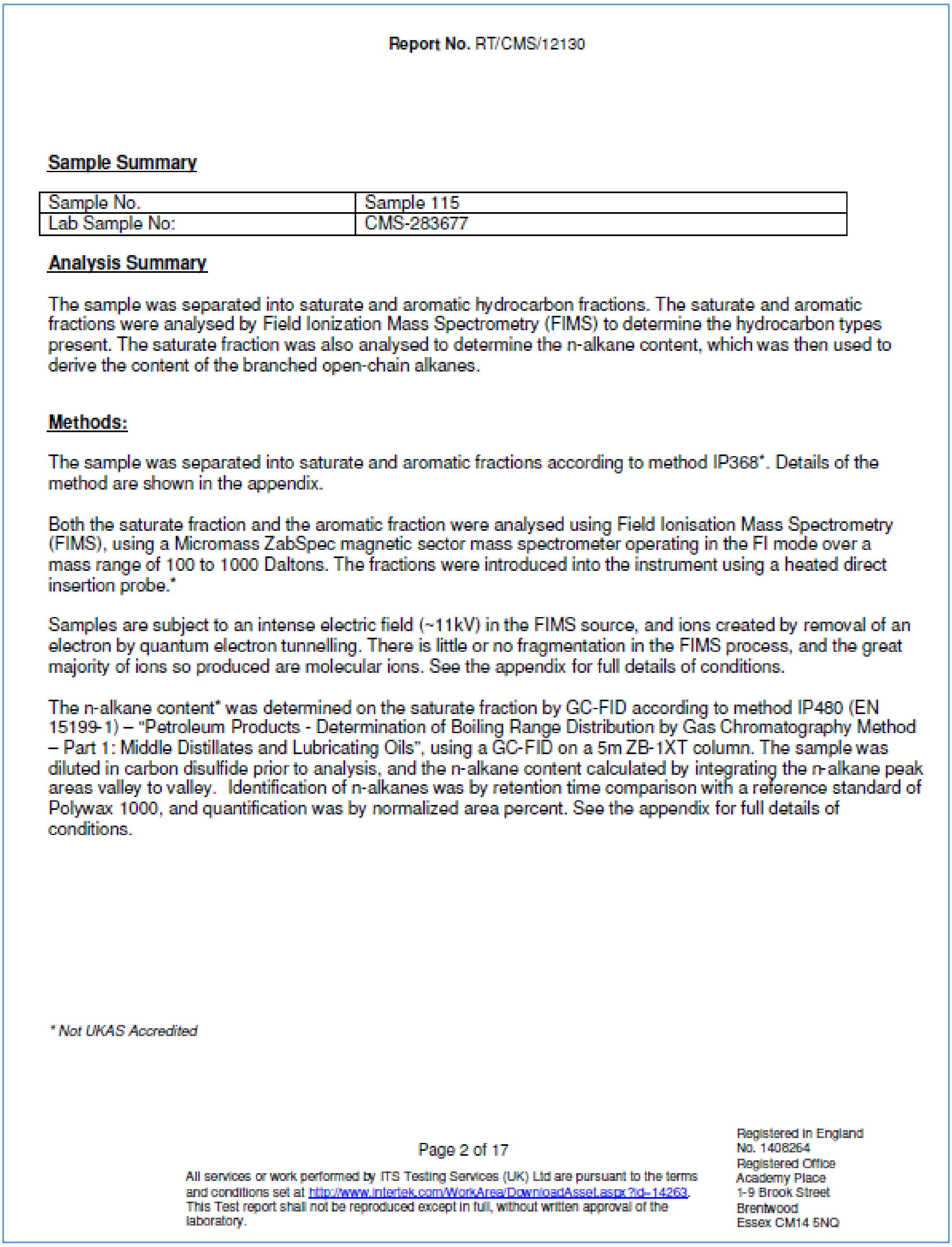


Report No. RT/CMS/12130

Sample Summary

Sample No.	Sample 115
Lab Sample No:	CMS-283677

Analysis Summary

The sample was separated into saturate and aromatic hydrocarbon fractions. The saturate and aromatic fractions were analysed by Field Ionization Mass Spectrometry (FIMS) to determine the hydrocarbon types present. The saturate fraction was also analysed to determine the n-alkane content, which was then used to derive the content of the branched open-chain alkanes.

Methods:

The sample was separated into saturate and aromatic fractions according to method IP368*. Details of the method are shown in the appendix.

Both the saturate fraction and the aromatic fraction were analysed using Field Ionisation Mass Spectrometry (FIMS), using a Micromass ZabSpec magnetic sector mass spectrometer operating in the FI mode over a mass range of 100 to 1000 Daltons. The fractions were introduced into the instrument using a heated direct insertion probe.*

Samples are subject to an intense electric field (~11kV) in the FIMS source, and ions created by removal of an electron by quantum electron tunnelling. There is little or no fragmentation in the FIMS process, and the great majority of ions so produced are molecular ions. See the appendix for full details of conditions.

The n-alkane content* was determined on the saturate fraction by GC-FID according to method IP480 (EN 15199-1) – "Petroleum Products - Determination of Boiling Range Distribution by Gas Chromatography Method – Part 1: Middle Distillates and Lubricating Oils", using a GC-FID on a 5m ZB-1XT column. The sample was diluted in carbon disulfide prior to analysis, and the n-alkane content calculated by integrating the n-alkane peak areas valley to valley. Identification of n-alkanes was by retention time comparison with a reference standard of Polywax 1000, and quantification was by normalized area percent. See the appendix for full details of conditions.

** Not UKAS Accredited*

HPLC Results

Table 1 below shows the results from the HPLC separation giving the percentage of saturates and aromatics fractions obtained. Figure 1 shows the HPLC chromatogram with the refractive index (RI) and ultraviolet (UV) detector traces.

Table 1 IP368 Data

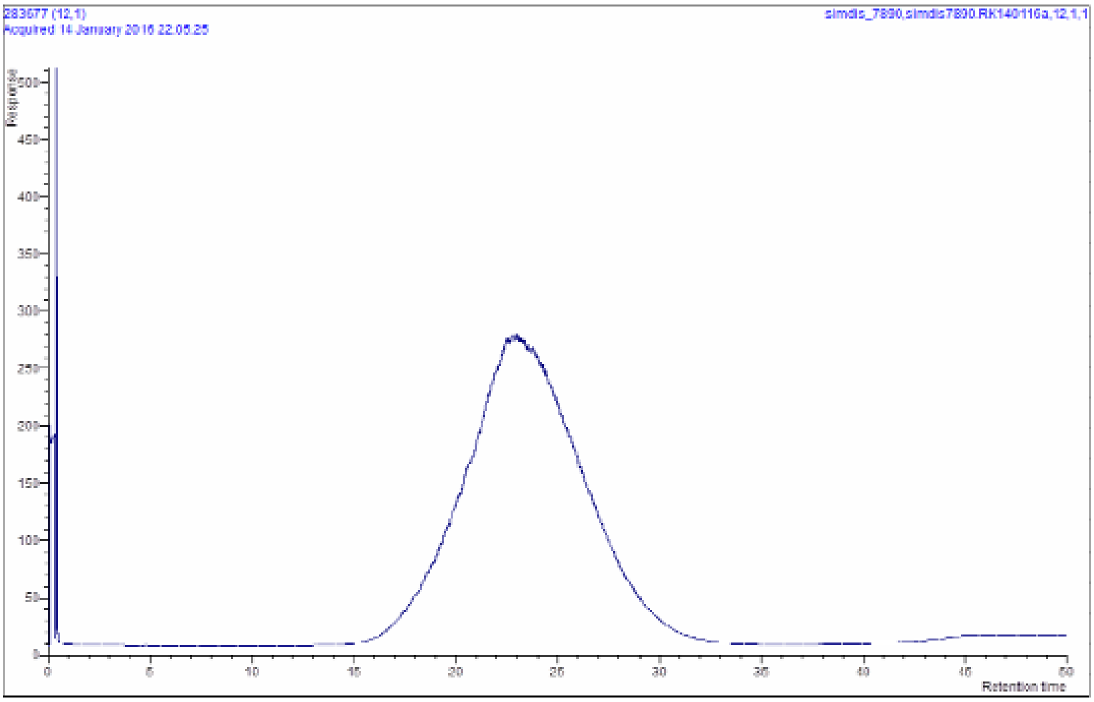
IP 368	%Wt
Saturates	96.3
Aromatics	3.7
Recovery	96.5

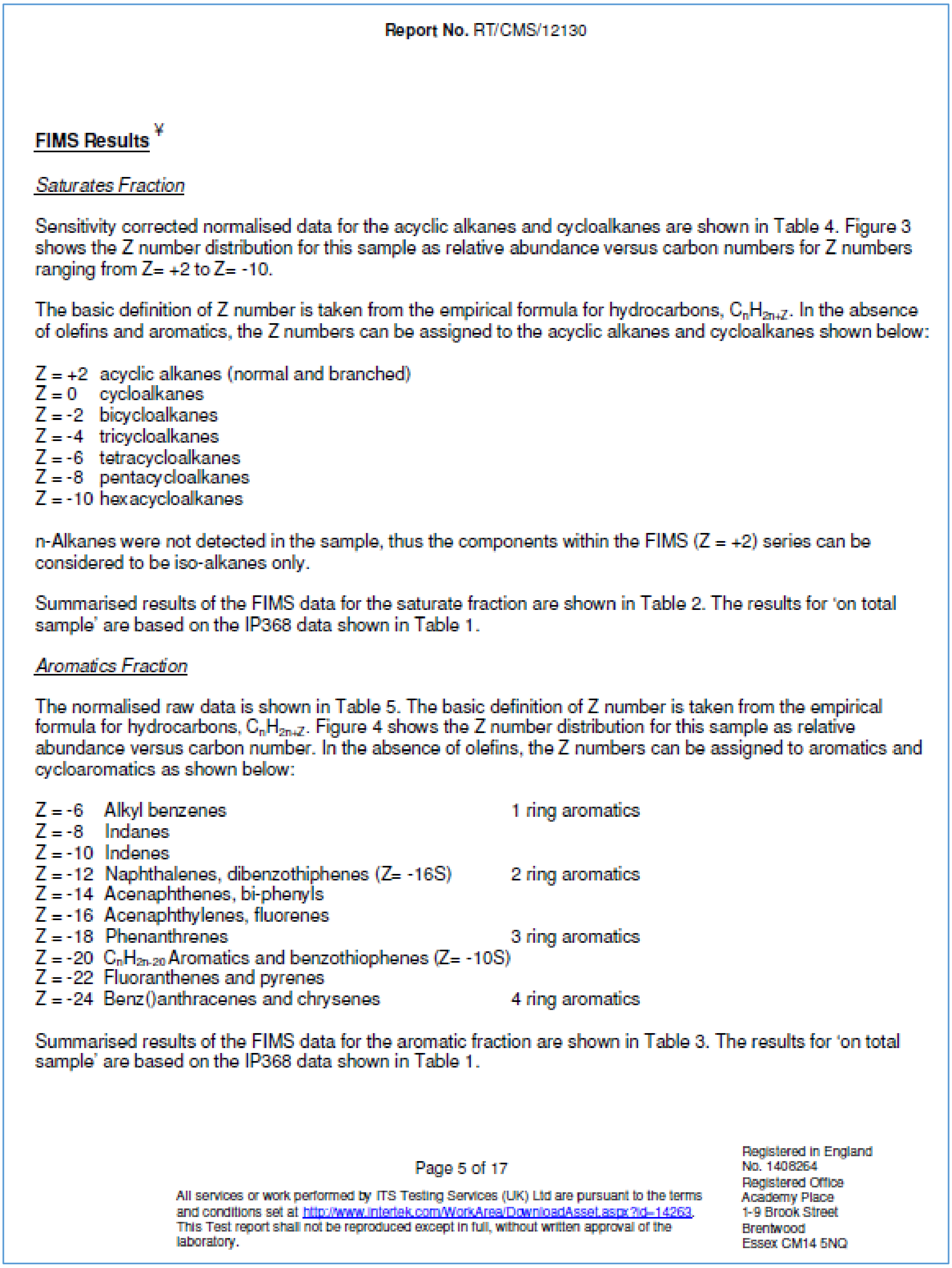
Figure 1 IP368 HPLC Chromatogram

GC Results

The GC chromatogram, figure 2, shows a profile of largely unresolved peaks. No significant n-alkanes were detected.

Figure 2 GC Chromatogram of saturate fraction CMS-283677.





FIMS Results [¥]

Saturates Fraction

Sensitivity corrected normalised data for the acyclic alkanes and cycloalkanes are shown in Table 4. Figure 3 shows the Z number distribution for this sample as relative abundance versus carbon numbers for Z numbers ranging from Z= +2 to Z= -10.

The basic definition of Z number is taken from the empirical formula for hydrocarbons, C_nH_{2n+Z}. In the absence of olefins and aromatics, the Z numbers can be assigned to the acyclic alkanes and cycloalkanes shown below:

Z = +2 acyclic alkanes (normal and branched)
Z = 0 cycloalkanes
Z = -2 bicycloalkanes
Z = -4 tricycloalkanes
Z = -6 tetracycloalkanes
Z = -8 pentacycloalkanes
Z = -10 hexacycloalkanes

n-Alkanes were not detected in the sample, thus the components within the FIMS (Z = +2) series can be considered to be iso-alkanes only.

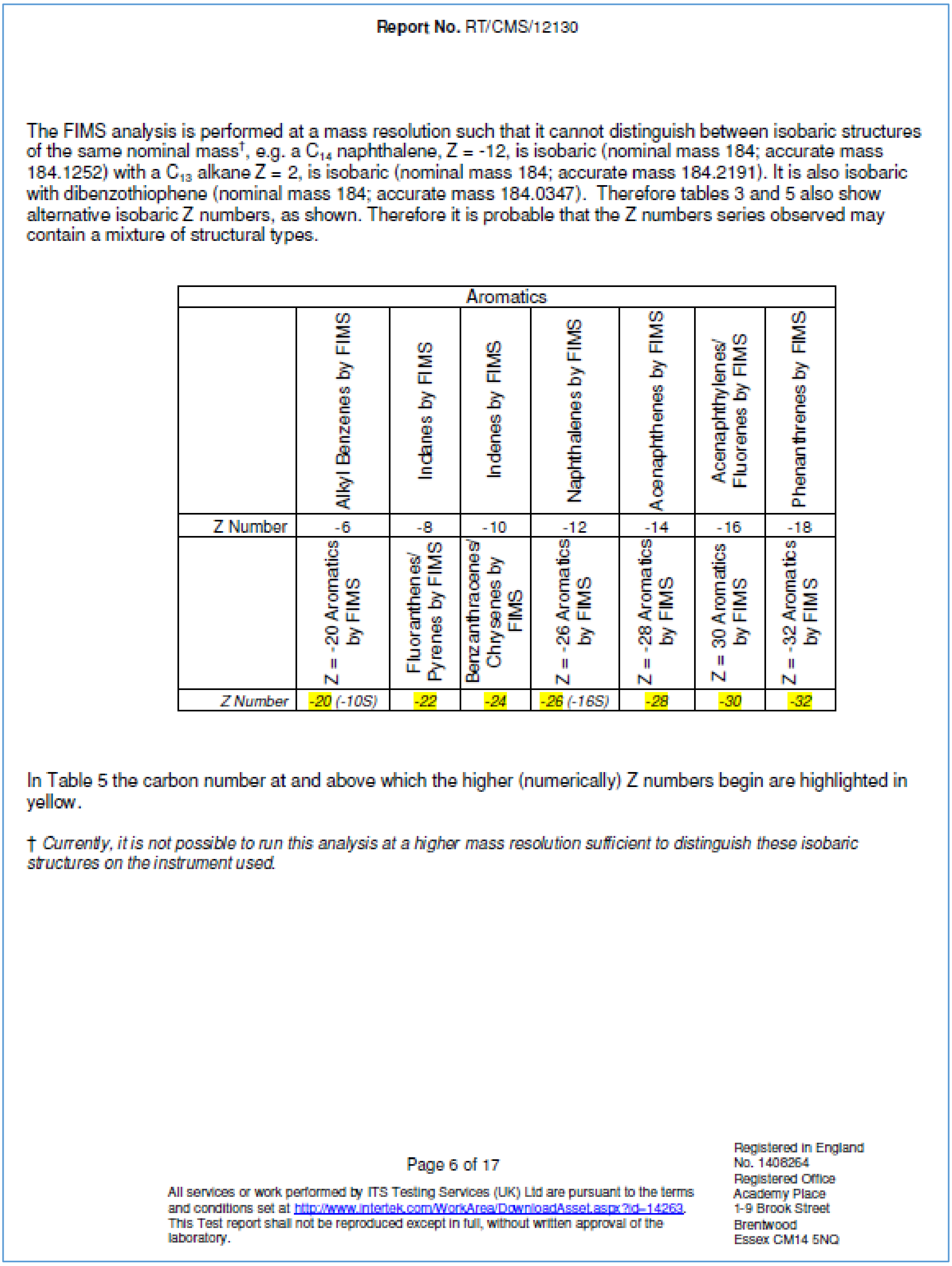
Summarised results of the FIMS data for the saturate fraction are shown in Table 2. The results for 'on total sample' are based on the IP368 data shown in Table 1.

Aromatics Fraction

The normalised raw data is shown in Table 5. The basic definition of Z number is taken from the empirical formula for hydrocarbons, C_nH_{2n+Z}. Figure 4 shows the Z number distribution for this sample as relative abundance versus carbon number. In the absence of olefins, the Z numbers can be assigned to aromatics and cycloaromatics as shown below:

Z = -6	Alkyl benzenes	1 ring aromatics
Z = -8	Indanes	
Z = -10	Indenes	
Z = -12	Naphthalenes, dibenzothiphenes (Z= -16S)	2 ring aromatics
Z = -14	Acenaphthenes, bi-phenyls	
Z = -16	Acenaphthylenes, fluorenes	
Z = -18	Phenanthrenes	3 ring aromatics
Z = -20	C_nH_{2n-20} Aromatics and benzothiophenes (Z= -10S)	
Z = -22	Fluoranthenes and pyrenes	
Z = -24	Benz()anthracenes and chrysenes	4 ring aromatics

Summarised results of the FIMS data for the aromatic fraction are shown in Table 3. The results for 'on total sample' are based on the IP368 data shown in Table 1.



The FIMS analysis is performed at a mass resolution such that it cannot distinguish between isobaric structures of the same nominal mass†, e.g. a C_{14} naphthalene, Z = -12, is isobaric (nominal mass 184; accurate mass 184.1252) with a C_{13} alkane Z = 2, is isobaric (nominal mass 184; accurate mass 184.2191). It is also isobaric with dibenzothiophene (nominal mass 184; accurate mass 184.0347). Therefore tables 3 and 5 also show alternative isobaric Z numbers, as shown. Therefore it is probable that the Z numbers series observed may contain a mixture of structural types.

	Aromatics						
	Alkyl Benzenes by FIMS	Indanes by FIMS	Indenes by FIMS	Naphthalenes by FIMS	Acenaphthenes by FIMS	Acenaphthylenes/ Fluorenes by FIMS	Phenanthrenes by FIMS
Z Number	-6	-8	-10	-12	-14	-16	-18
	Z = -20 Aromatics by FIMS	Fluoranthenes/ Pyrenes by FIMS	Benzanthracenes/ Chrysenes by FIMS	Z = -26 Aromatics by FIMS	Z = -28 Aromatics by FIMS	Z = -30 Aromatics by FIMS	Z = -32 Aromatics by FIMS
Z Number	*-20 (-10S)*	*-22*	*-24*	*-26 (-16S)*	*-28*	*-30*	*-32*

In Table 5 the carbon number at and above which the higher (numerically) Z numbers begin are highlighted in yellow.

† *Currently, it is not possible to run this analysis at a higher mass resolution sufficient to distinguish these isobaric structures on the instrument used.*

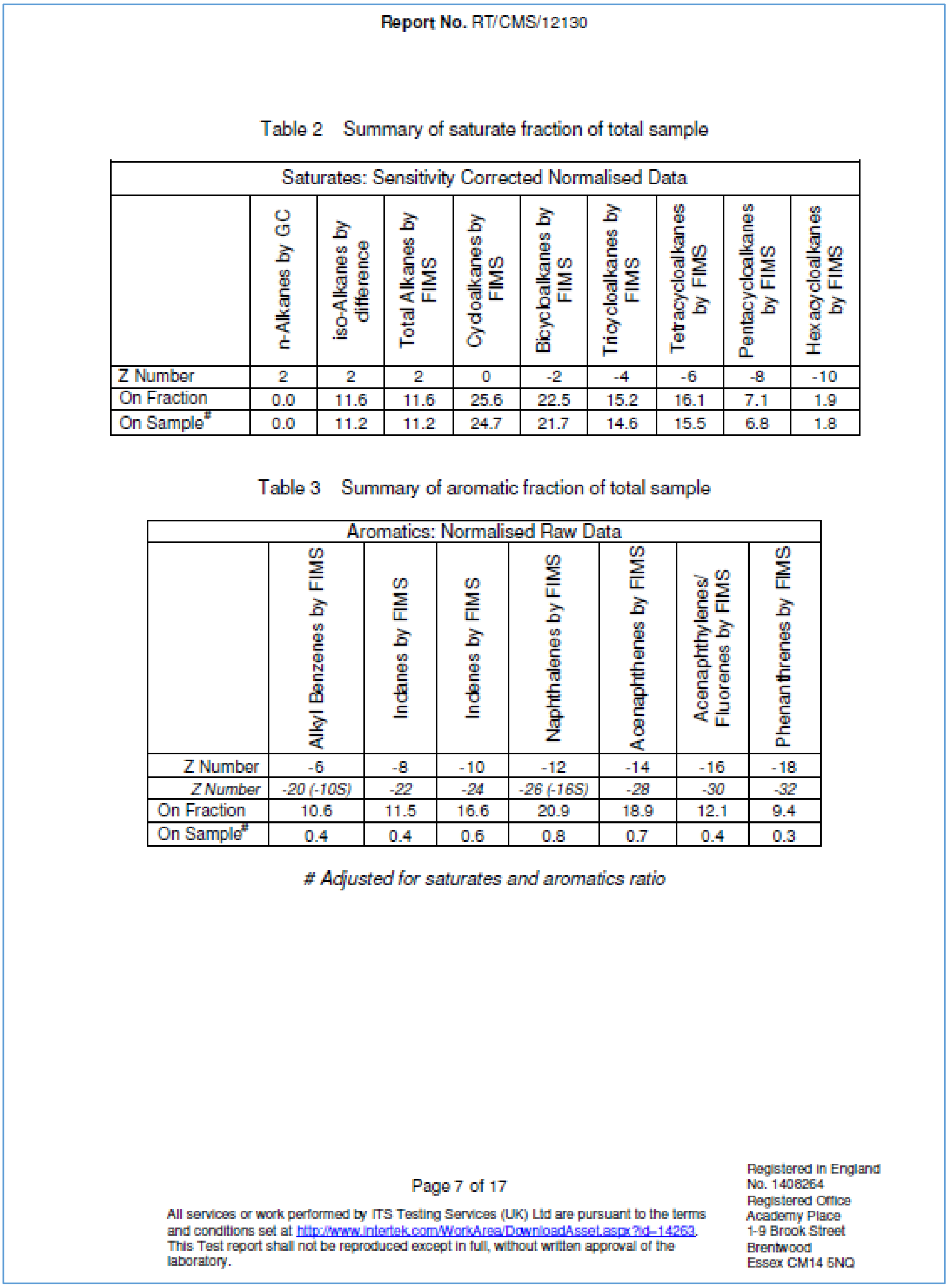


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Table 2 Summary of saturate fraction of total sample

Saturates: Sensitivity Corrected Normalised Data	n-Alkanes by GC	iso-Alkanes by difference	Total Alkanes by FIMS	Cycloalkanes by FIMS	Bicycloalkanes by FIMS	Tricycloalkanes by FIMS	Tetracycloalkanes by FIMS	Pentacycloalkanes by FIMS	Hexacycloalkanes by FIMS
Z Number	2	2	2	0	-2	-4	-6	-8	-10
On Fraction	0.0	11.6	11.6	25.6	22.5	15.2	16.1	7.1	1.9
On Sample#	0.0	11.2	11.2	24.7	21.7	14.6	15.5	6.8	1.8

Table 3 Summary of aromatic fraction of total sample

Aromatics: Normalised Raw Data	Alkyl Benzenes by FIMS	Indanes by FIMS	Indenes by FIMS	Naphthalenes by FIMS	Acenaphthenes by FIMS	Acenaphthylenes/ Fluorenes by FIMS	Phenanthrenes by FIMS
Z Number	-6	-8	-10	-12	-14	-16	-18
Z Number	*-20 (-10S)*	*-22*	*-24*	*-26 (-16S)*	*-28*	*-30*	*-32*
On Fraction	10.6	11.5	16.6	20.9	18.9	12.1	9.4
On Sample#	0.4	0.4	0.6	0.8	0.7	0.4	0.3

 # Adjusted for saturates and aromatics ratio

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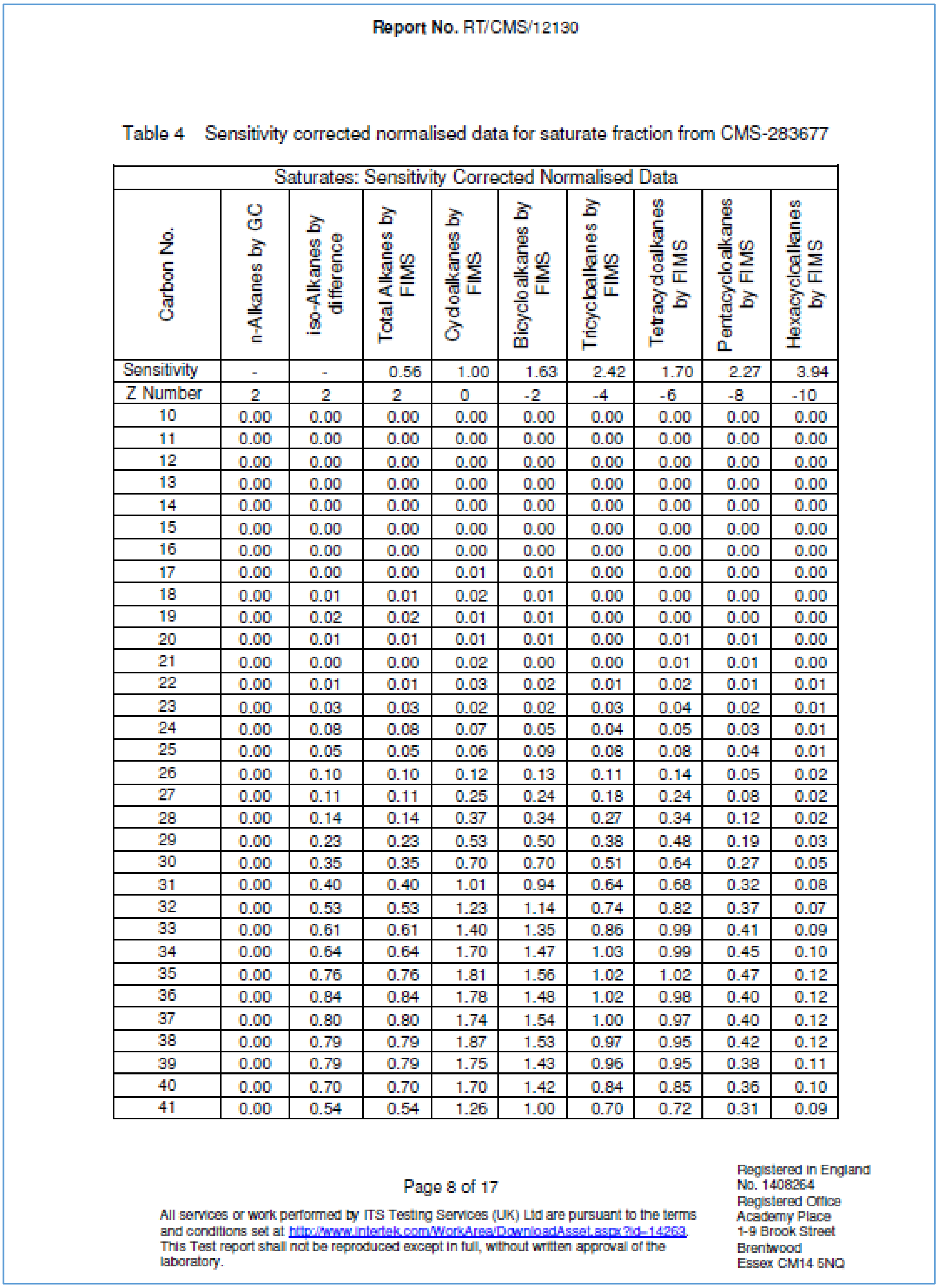

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Table 4 Sensitivity corrected normalised data for saturate fraction from CMS-283677

Saturates: Sensitivity Corrected Normalised Data									
Carbon No.	n-Alkanes by GC	iso-Alkanes by difference	Total Alkanes by FIMS	Cycloalkanes by FIMS	Bicycloalkanes by FIMS	Tricycloalkanes by FIMS	Tetracycloalkanes by FIMS	Pentacycloalkanes by FIMS	Hexacycloalkanes by FIMS
Sensitivity	-	-	0.56	1.00	1.63	2.42	1.70	2.27	3.94
Z Number	2	2	2	0	-2	-4	-6	-8	-10
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
18	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00
19	0.00	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
20	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00
21	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.00
22	0.00	0.01	0.01	0.03	0.02	0.01	0.02	0.01	0.01
23	0.00	0.03	0.03	0.02	0.02	0.03	0.04	0.02	0.01
24	0.00	0.08	0.08	0.07	0.05	0.04	0.05	0.03	0.01
25	0.00	0.05	0.05	0.06	0.09	0.08	0.08	0.04	0.01
26	0.00	0.10	0.10	0.12	0.13	0.11	0.14	0.05	0.02
27	0.00	0.11	0.11	0.25	0.24	0.18	0.24	0.08	0.02
28	0.00	0.14	0.14	0.37	0.34	0.27	0.34	0.12	0.02
29	0.00	0.23	0.23	0.53	0.50	0.38	0.48	0.19	0.03
30	0.00	0.35	0.35	0.70	0.70	0.51	0.64	0.27	0.05
31	0.00	0.40	0.40	1.01	0.94	0.64	0.68	0.32	0.08
32	0.00	0.53	0.53	1.23	1.14	0.74	0.82	0.37	0.07
33	0.00	0.61	0.61	1.40	1.35	0.86	0.99	0.41	0.09
34	0.00	0.64	0.64	1.70	1.47	1.03	0.99	0.45	0.10
35	0.00	0.76	0.76	1.81	1.56	1.02	1.02	0.47	0.12
36	0.00	0.84	0.84	1.78	1.48	1.02	0.98	0.40	0.12
37	0.00	0.80	0.80	1.74	1.54	1.00	0.97	0.40	0.12
38	0.00	0.79	0.79	1.87	1.53	0.97	0.95	0.42	0.12
39	0.00	0.79	0.79	1.75	1.43	0.96	0.95	0.38	0.11
40	0.00	0.70	0.70	1.70	1.42	0.84	0.85	0.36	0.10
41	0.00	0.54	0.54	1.26	1.00	0.70	0.72	0.31	0.09

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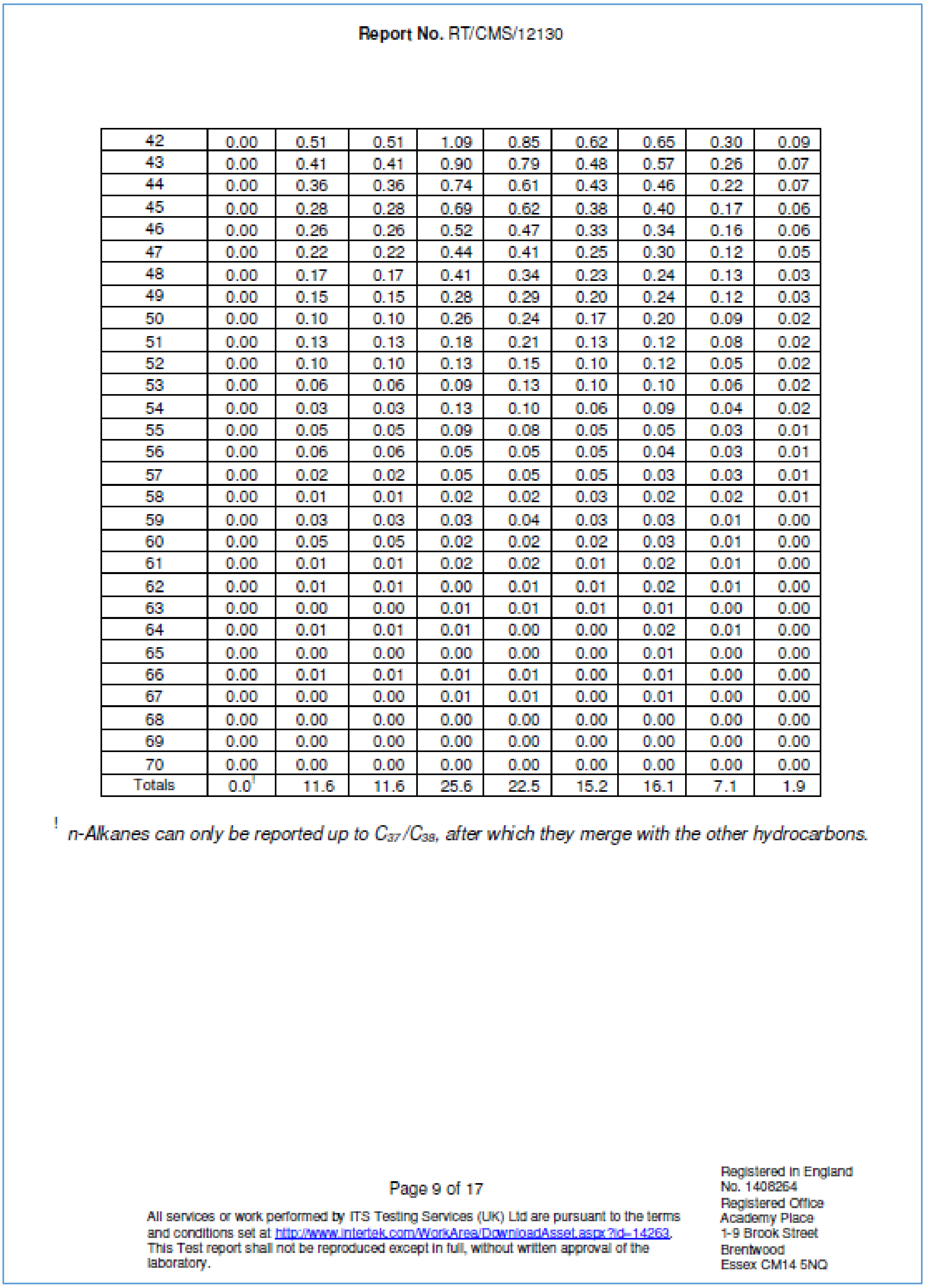

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42	0.00	0.51	0.51	1.09	0.85	0.62	0.65	0.30	0.09
43	0.00	0.41	0.41	0.90	0.79	0.48	0.57	0.26	0.07
44	0.00	0.36	0.36	0.74	0.61	0.43	0.46	0.22	0.07
45	0.00	0.28	0.28	0.69	0.62	0.38	0.40	0.17	0.06
46	0.00	0.26	0.26	0.52	0.47	0.33	0.34	0.16	0.06
47	0.00	0.22	0.22	0.44	0.41	0.25	0.30	0.12	0.05
48	0.00	0.17	0.17	0.41	0.34	0.23	0.24	0.13	0.03
49	0.00	0.15	0.15	0.28	0.29	0.20	0.24	0.12	0.03
50	0.00	0.10	0.10	0.26	0.24	0.17	0.20	0.09	0.02
51	0.00	0.13	0.13	0.18	0.21	0.13	0.12	0.08	0.02
52	0.00	0.10	0.10	0.13	0.15	0.10	0.12	0.05	0.02
53	0.00	0.06	0.06	0.09	0.13	0.10	0.10	0.06	0.02
54	0.00	0.03	0.03	0.13	0.10	0.06	0.09	0.04	0.02
55	0.00	0.05	0.05	0.09	0.08	0.05	0.05	0.03	0.01
56	0.00	0.06	0.06	0.05	0.05	0.05	0.04	0.03	0.01
57	0.00	0.02	0.02	0.05	0.05	0.05	0.03	0.03	0.01
58	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01
59	0.00	0.03	0.03	0.03	0.04	0.03	0.03	0.01	0.00
60	0.00	0.05	0.05	0.02	0.02	0.02	0.03	0.01	0.00
61	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.00
62	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.00
63	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00
64	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
66	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00
67	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.0[!]	11.6	11.6	25.6	22.5	15.2	16.1	7.1	1.9

[!] *n-Alkanes can only be reported up to C_{37}/C_{38}, after which they merge with the other hydrocarbons.*

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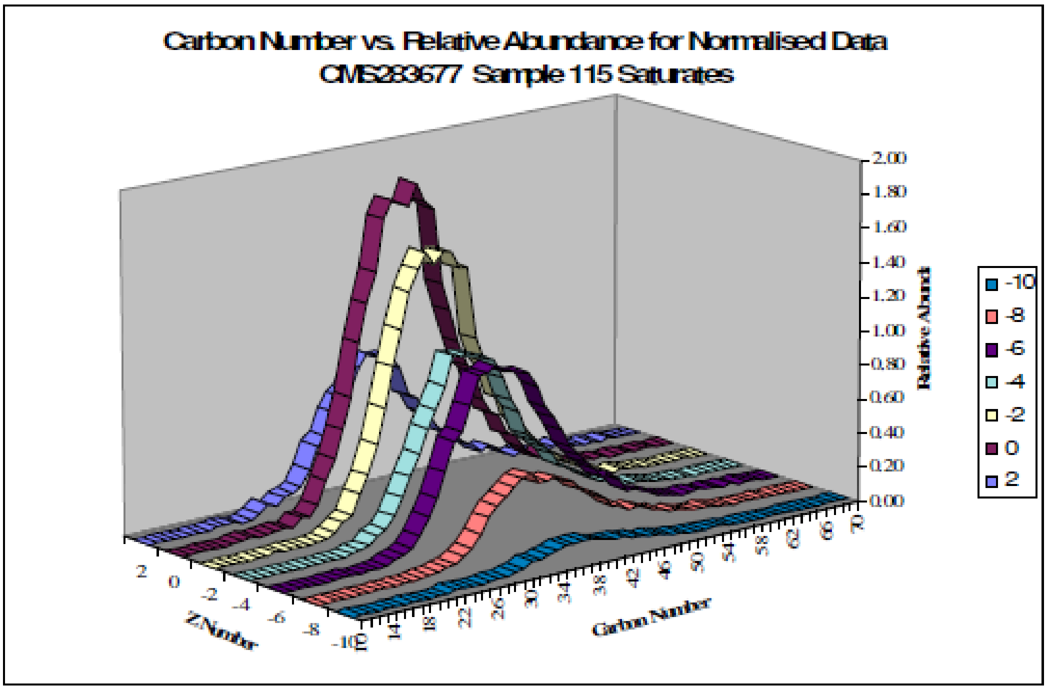
Figure 3 Z number distribution of sample CMS-283677 saturate fraction



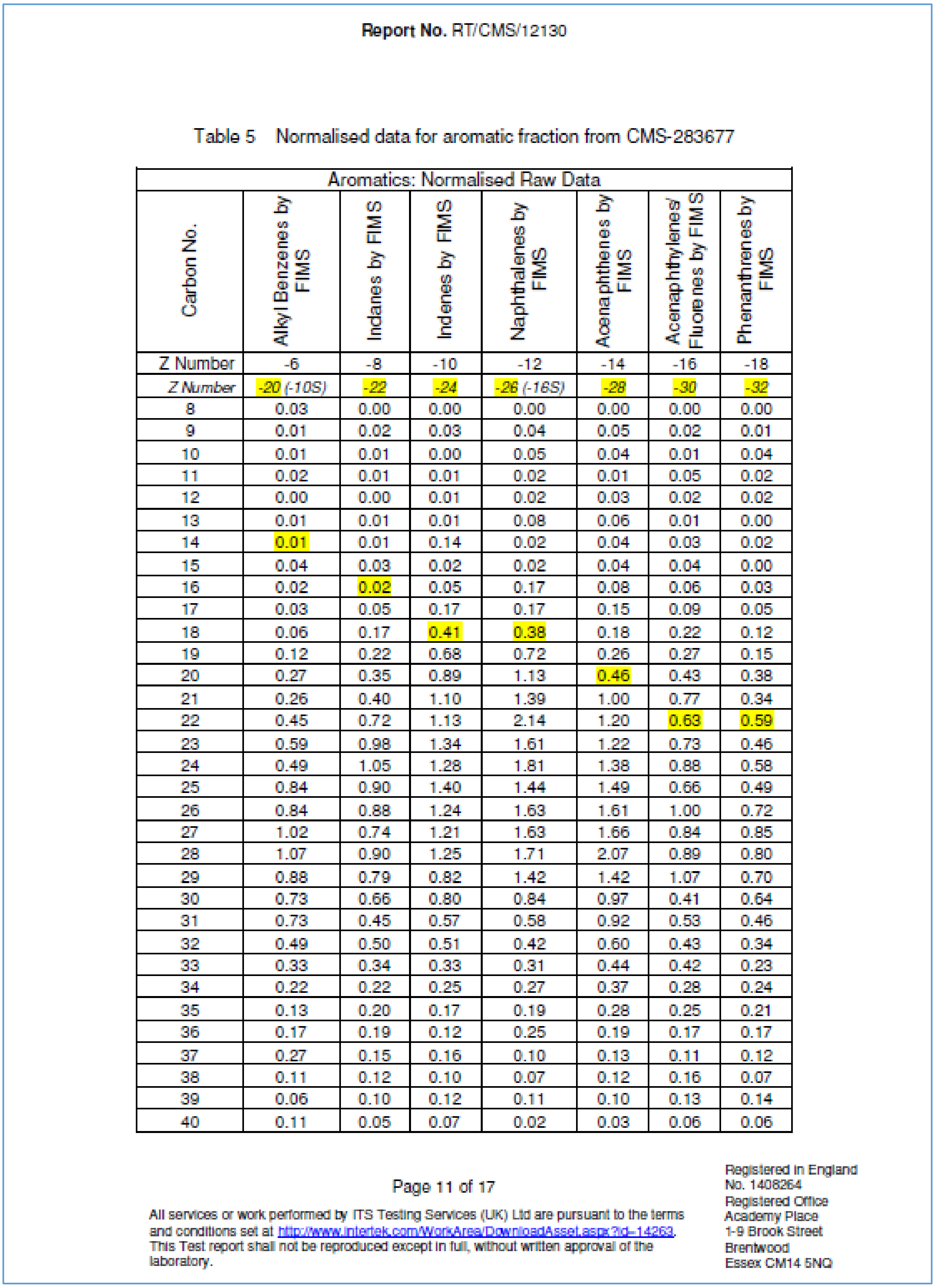


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Table 5 Normalised data for aromatic fraction from CMS-283677

Aromatics: Normalised Raw Data							
Carbon No.	Alkyl Benzenes by FIMS	Indanes by FIMS	Indenes by FIMS	Naphthalenes by FIMS	Acenaphthenes by FIMS	Acenaphthylenes/ Fluorenes by FIMS	Phenanthrenes by FIMS
Z Number	-6	-8	-10	-12	-14	-16	-18
Z Number	*-20 (-10S)*	*-22*	*-24*	*-26 (-16S)*	*-28*	*-30*	*-32*
8	0.03	0.00	0.00	0.00	0.00	0.00	0.00
9	0.01	0.02	0.03	0.04	0.05	0.02	0.01
10	0.01	0.01	0.00	0.05	0.04	0.01	0.04
11	0.02	0.01	0.01	0.02	0.01	0.05	0.02
12	0.00	0.00	0.01	0.02	0.03	0.02	0.02
13	0.01	0.01	0.01	0.08	0.06	0.01	0.00
14	0.01	0.01	0.14	0.02	0.04	0.03	0.02
15	0.04	0.03	0.02	0.02	0.04	0.04	0.00
16	0.02	0.02	0.05	0.17	0.08	0.06	0.03
17	0.03	0.05	0.17	0.17	0.15	0.09	0.05
18	0.06	0.17	0.41	0.38	0.18	0.22	0.12
19	0.12	0.22	0.68	0.72	0.26	0.27	0.15
20	0.27	0.35	0.89	1.13	0.46	0.43	0.38
21	0.26	0.40	1.10	1.39	1.00	0.77	0.34
22	0.45	0.72	1.13	2.14	1.20	0.63	0.59
23	0.59	0.98	1.34	1.61	1.22	0.73	0.46
24	0.49	1.05	1.28	1.81	1.38	0.88	0.58
25	0.84	0.90	1.40	1.44	1.49	0.66	0.49
26	0.84	0.88	1.24	1.63	1.61	1.00	0.72
27	1.02	0.74	1.21	1.63	1.66	0.84	0.85
28	1.07	0.90	1.25	1.71	2.07	0.89	0.80
29	0.88	0.79	0.82	1.42	1.42	1.07	0.70
30	0.73	0.66	0.80	0.84	0.97	0.41	0.64
31	0.73	0.45	0.57	0.58	0.92	0.53	0.46
32	0.49	0.50	0.51	0.42	0.60	0.43	0.34
33	0.33	0.34	0.33	0.31	0.44	0.42	0.23
34	0.22	0.22	0.25	0.27	0.37	0.28	0.24
35	0.13	0.20	0.17	0.19	0.28	0.25	0.21
36	0.17	0.19	0.12	0.25	0.19	0.17	0.17
37	0.27	0.15	0.16	0.10	0.13	0.11	0.12
38	0.11	0.12	0.10	0.07	0.12	0.16	0.07
39	0.06	0.10	0.12	0.11	0.10	0.13	0.14
40	0.11	0.05	0.07	0.02	0.03	0.06	0.06

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41	0.01	0.09	0.06	0.02	0.06	0.06	0.09
42	0.05	0.03	0.06	0.01	0.04	0.04	0.05
43	0.03	0.01	0.02	0.02	0.00	0.06	0.06
44	0.04	0.01	0.04	0.03	0.02	0.03	0.06
45	0.04	0.04	0.01	0.04	0.04	0.01	0.06
46	0.00	0.01	0.01	0.00	0.04	0.03	0.00
47	0.00	0.01	0.00	0.00	0.01	0.09	0.00
48	0.03	0.03	0.00	0.00	0.01	0.06	0.02
49	0.00	0.01	0.01	0.02	0.01	0.00	0.00
50	0.01	0.00	0.00	0.01	0.00	0.01	0.01
51	0.00	0.00	0.00	0.00	0.01	0.00	0.01
52	0.00	0.00	0.00	0.01	0.01	0.00	0.00
53	0.00	0.01	0.00	0.00	0.01	0.00	0.00
54	0.00	0.00	0.00	0.00	0.01	0.00	0.01
55	0.01	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.01	0.00	0.00	0.00	0.01
57	0.00	0.00	0.01	0.00	0.00	0.01	0.00
58	0.00	0.00	0.00	0.00	0.01	0.00	0.00
59	0.00	0.00	0.00	0.00	0.00	0.02	0.00
60	0.01	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.01	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00	0.00	0.00	0.03
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals %	10.6	11.5	16.6	20.9	18.9	12.1	9.4

Note: the amount of material isolated as aromatic fraction was very low and gave a very weak signal by FIMS (and a very weak UV signal in the HPLC separation), thus the data should be treated with caution.

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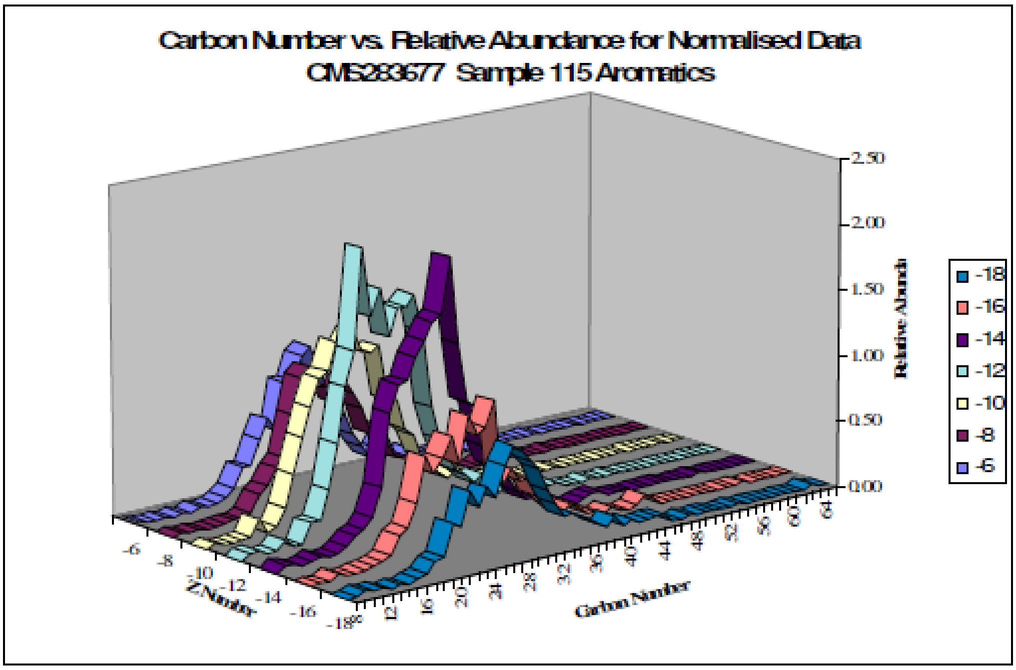
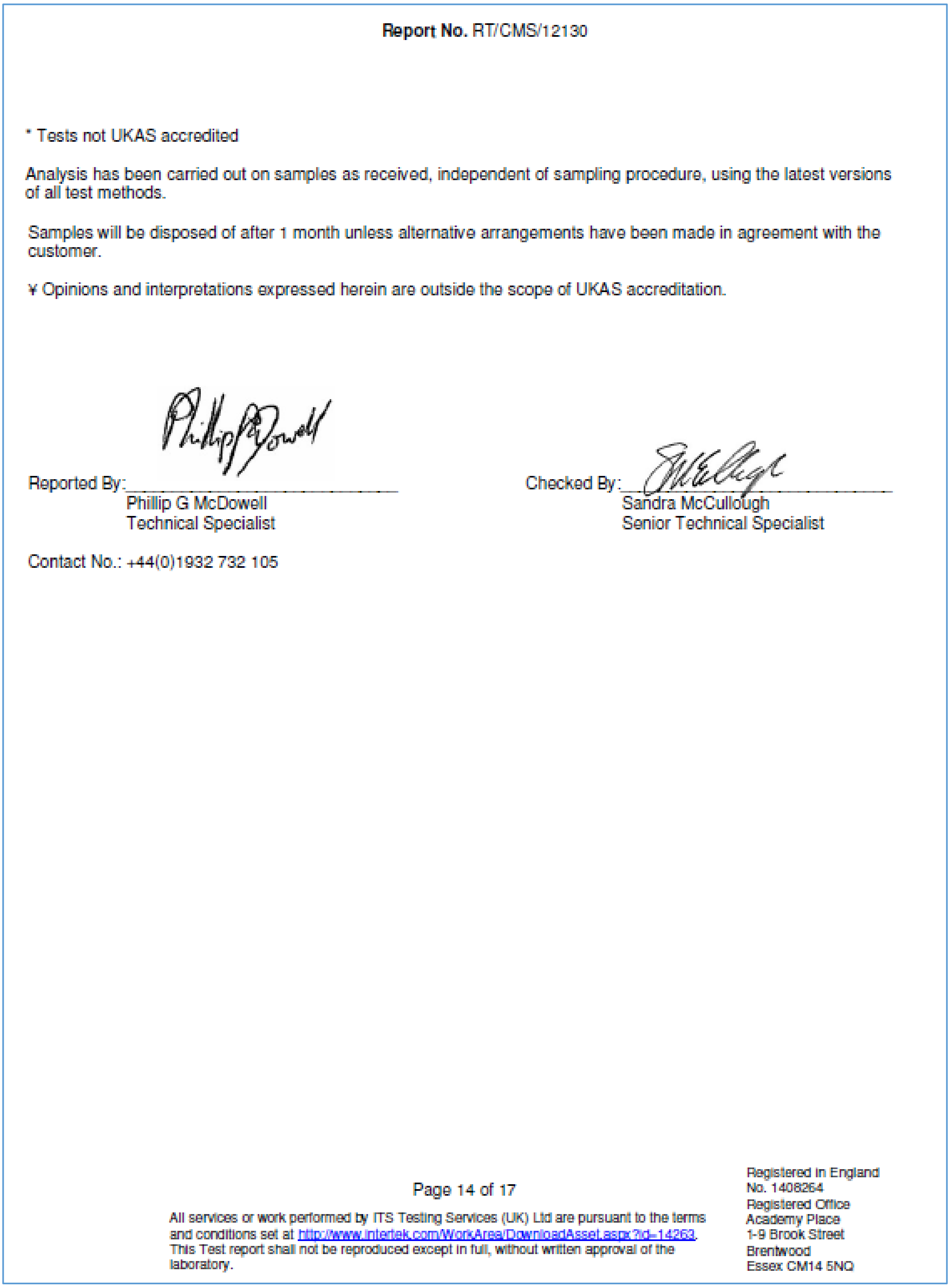
Figure 4 Z number distribution of sample CMS-283677 aromatic fraction





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* Tests not UKAS accredited

Analysis has been carried out on samples as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

¥ Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Phillip McDowell

Reported By:______________________________
Phillip G McDowell
Technical Specialist

Checked By:______________________________
Sandra McCullough
Senior Technical Specialist

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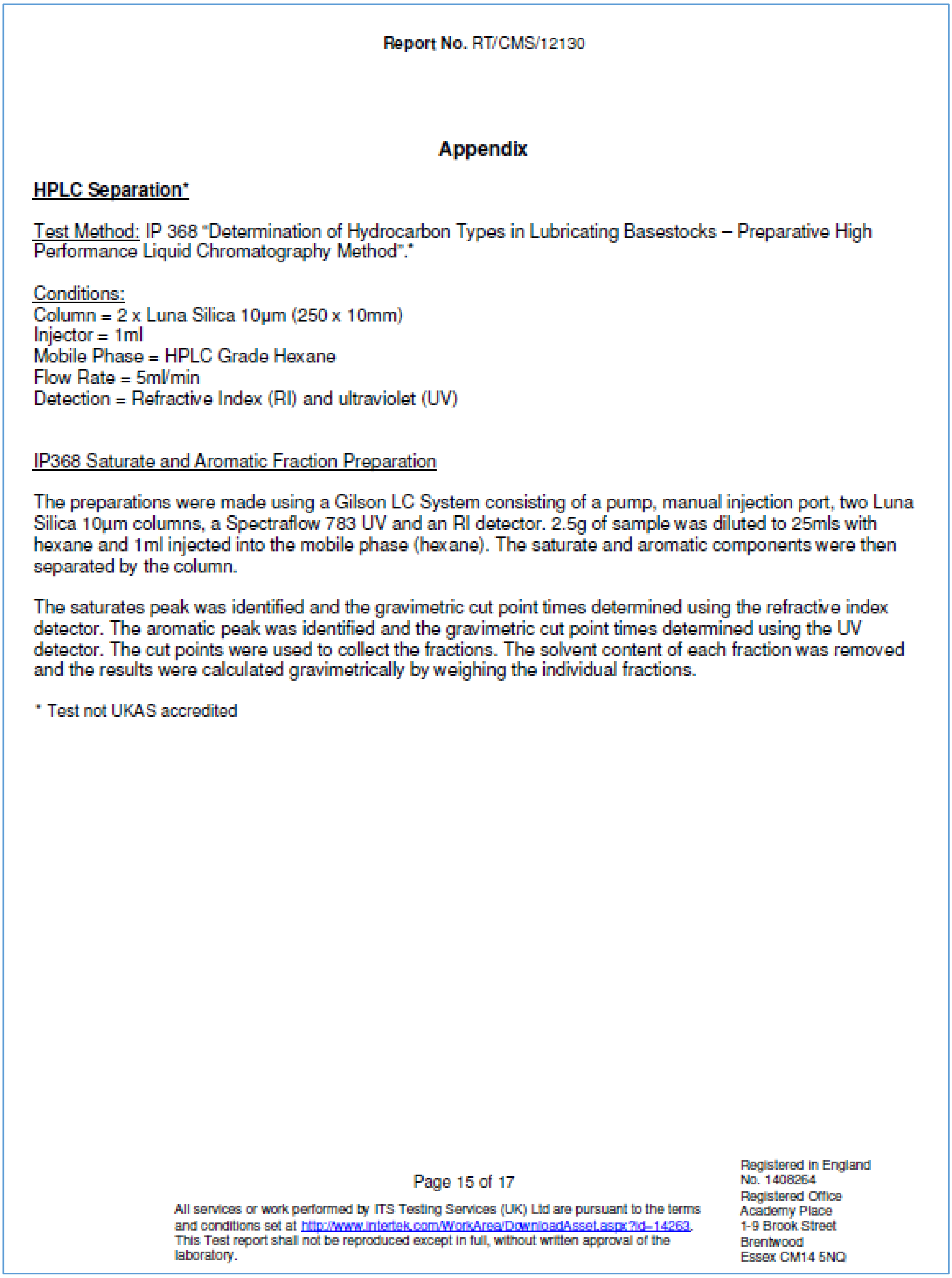


Appendix

HPLC Separation*

Test Method: IP 368 "Determination of Hydrocarbon Types in Lubricating Basestocks – Preparative High Performance Liquid Chromatography Method".*

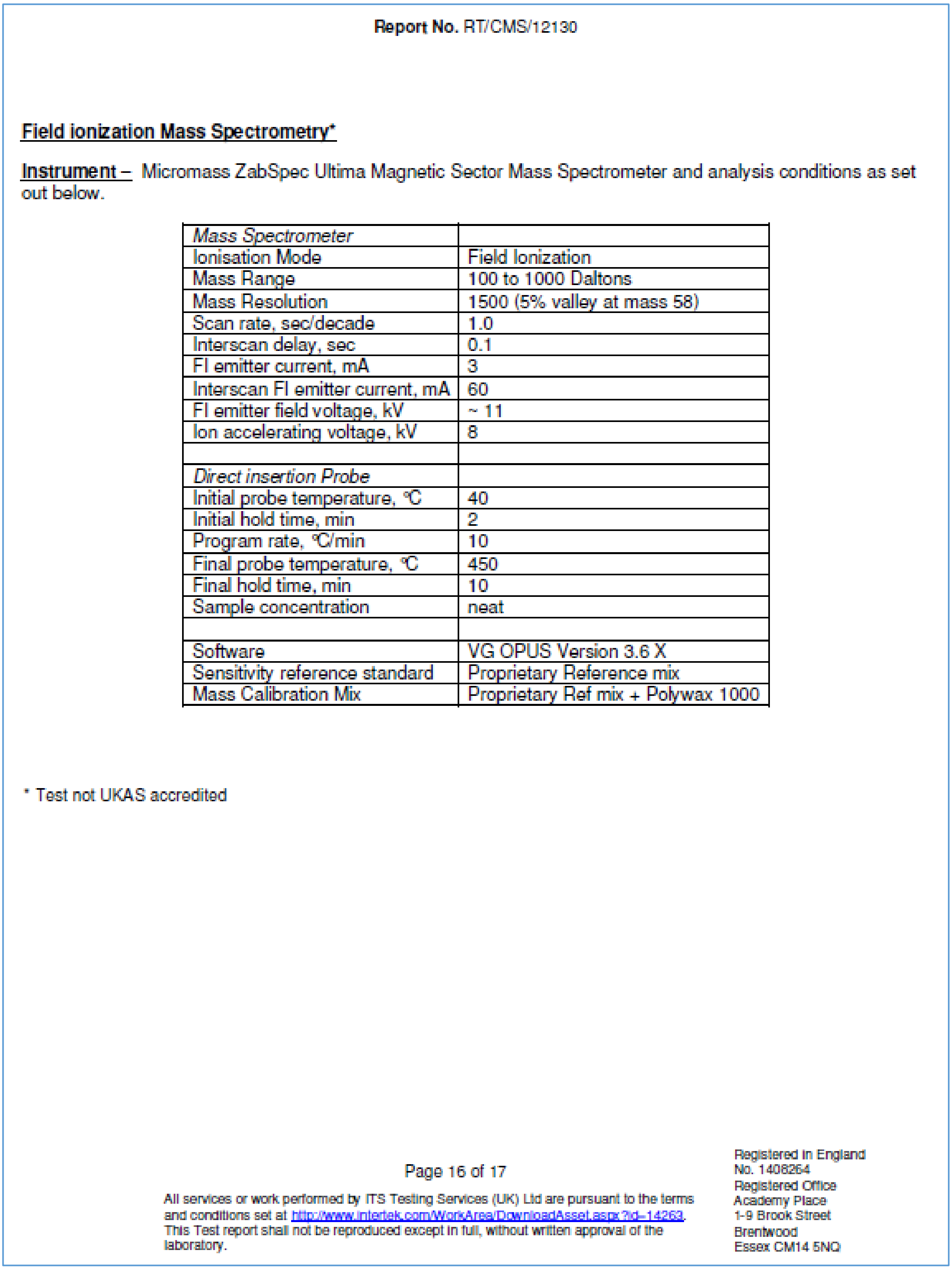
Conditions:
Column = 2 x Luna Silica 10µm (250 x 10mm)
Injector = 1ml
Mobile Phase = HPLC Grade Hexane
Flow Rate = 5ml/min
Detection = Refractive Index (RI) and ultraviolet (UV)

IP368 Saturate and Aromatic Fraction Preparation

The preparations were made using a Gilson LC System consisting of a pump, manual injection port, two Luna Silica 10µm columns, a Spectraflow 783 UV and an RI detector. 2.5g of sample was diluted to 25mls with hexane and 1ml injected into the mobile phase (hexane). The saturate and aromatic components were then separated by the column.

The saturates peak was identified and the gravimetric cut point times determined using the refractive index detector. The aromatic peak was identified and the gravimetric cut point times determined using the UV detector. The cut points were used to collect the fractions. The solvent content of each fraction was removed and the results were calculated gravimetrically by weighing the individual fractions.

* Test not UKAS accredited

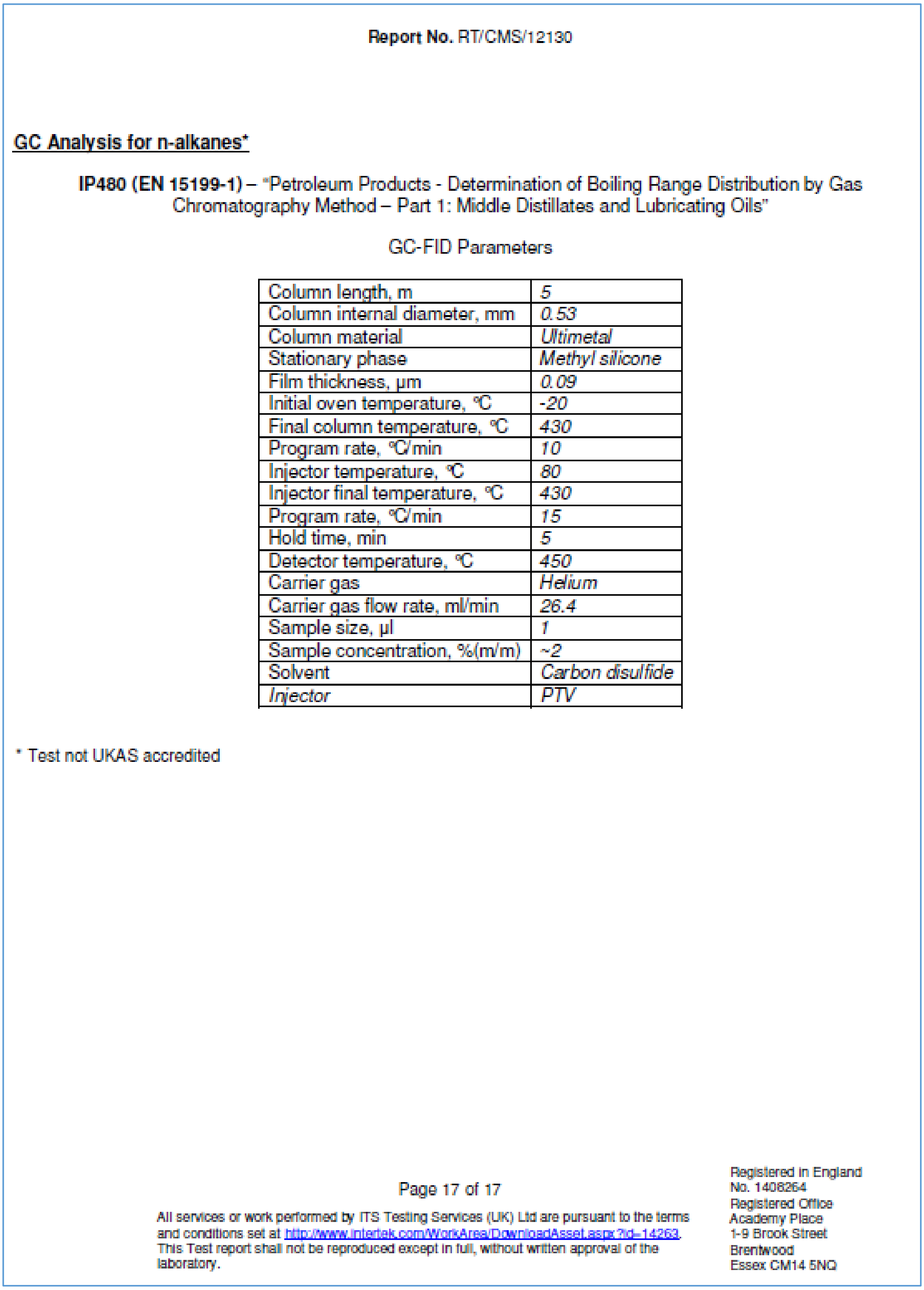


Field ionization Mass Spectrometry*

Instrument – Micromass ZabSpec Ultima Magnetic Sector Mass Spectrometer and analysis conditions as set out below.

Mass Spectrometer	
Ionisation Mode	Field Ionization
Mass Range	100 to 1000 Daltons
Mass Resolution	1500 (5% valley at mass 58)
Scan rate, sec/decade	1.0
Interscan delay, sec	0.1
FI emitter current, mA	3
Interscan FI emitter current, mA	60
FI emitter field voltage, kV	~ 11
Ion accelerating voltage, kV	8
Direct insertion Probe	
Initial probe temperature, °C	40
Initial hold time, min	2
Program rate, °C/min	10
Final probe temperature, °C	450
Final hold time, min	10
Sample concentration	neat
Software	VG OPUS Version 3.6 X
Sensitivity reference standard	Proprietary Reference mix
Mass Calibration Mix	Proprietary Ref mix + Polywax 1000

* Test not UKAS accredited



Report No. RT/CMS/12130

GC Analysis for n-alkanes*

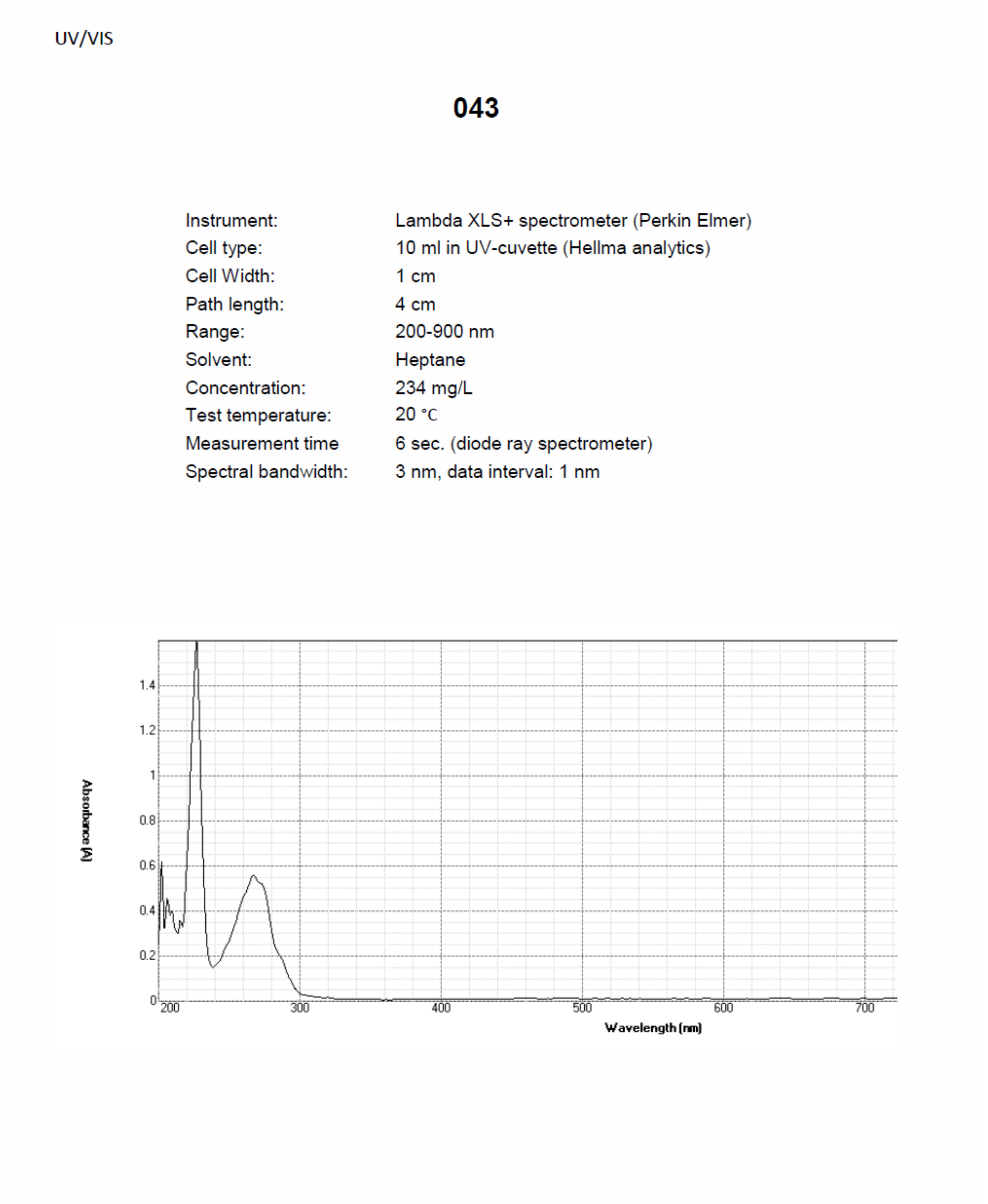
IP480 (EN 15199-1) – "Petroleum Products - Determination of Boiling Range Distribution by Gas Chromatography Method – Part 1: Middle Distillates and Lubricating Oils"

GC-FID Parameters

Column length, m	*5*
Column internal diameter, mm	*0.53*
Column material	*Ultimetal*
Stationary phase	*Methyl silicone*
Film thickness, µm	*0.09*
Initial oven temperature, °C	*-20*
Final column temperature, °C	*430*
Program rate, °C/min	*10*
Injector temperature, °C	*80*
Injector final temperature, °C	*430*
Program rate, °C/min	*15*
Hold time, min	*5*
Detector temperature, °C	*450*
Carrier gas	*Helium*
Carrier gas flow rate, ml/min	*26.4*
Sample size, µl	*1*
Sample concentration, %(m/m)	*~2*
Solvent	*Carbon disulfide*
Injector	*PTV*

* Test not UKAS accredited

APPENDIX 11(A) - EXAMPLE OF UV, IR AND NMR SPECTRA (SAMPLE 043 - KEROSINE)



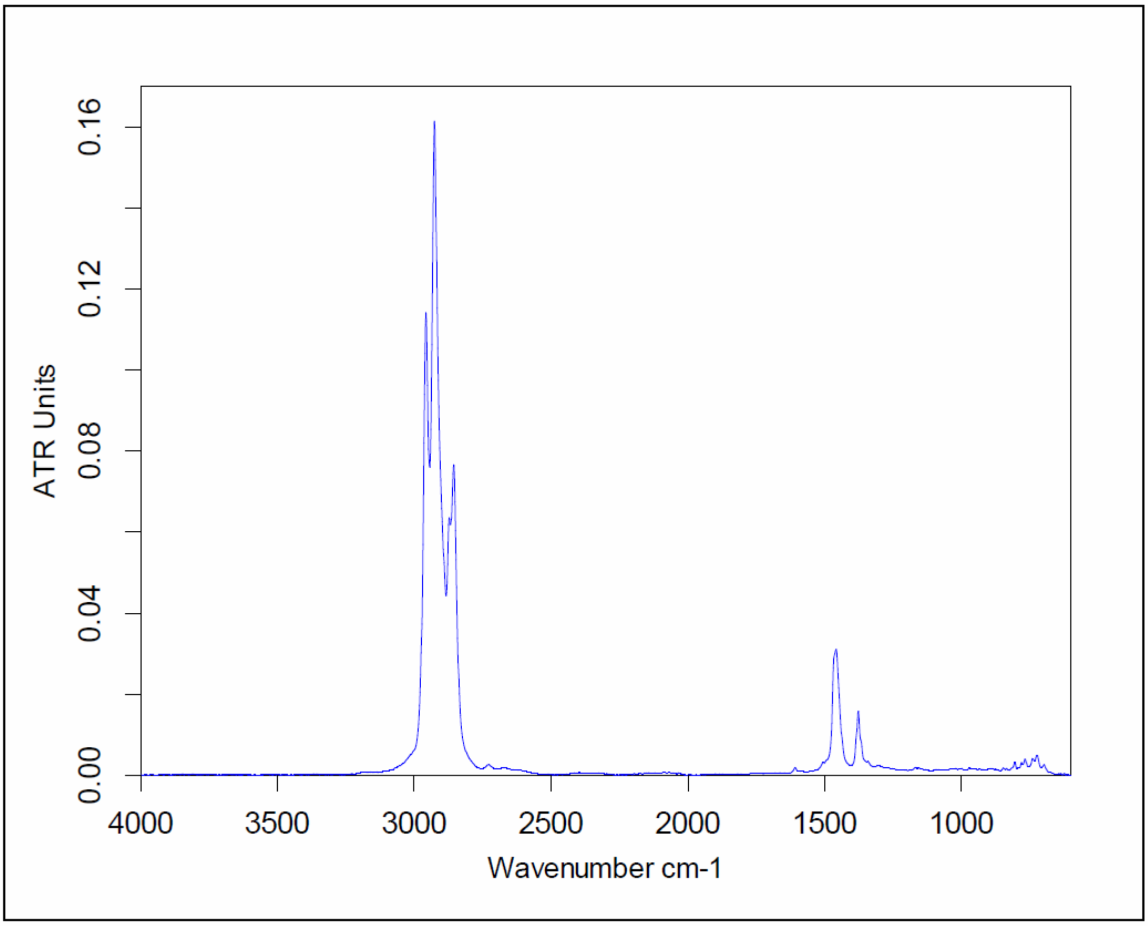
UV/VIS

043

Instrument:	Lambda XLS+ spectrometer (Perkin Elmer)
Cell type:	10 ml in UV-cuvette (Hellma analytics)
Cell Width:	1 cm
Path length:	4 cm
Range:	200-900 nm
Solvent:	Heptane
Concentration:	234 mg/L
Test temperature:	20 °C
Measurement time	6 sec. (diode ray spectrometer)
Spectral bandwidth:	3 nm, data interval: 1 nm

043

Instrument: Bruker Tensor 27 FTIR instrument
with ATR accessory
Number of scans: 16
Spectral resolution: 4 cm-1

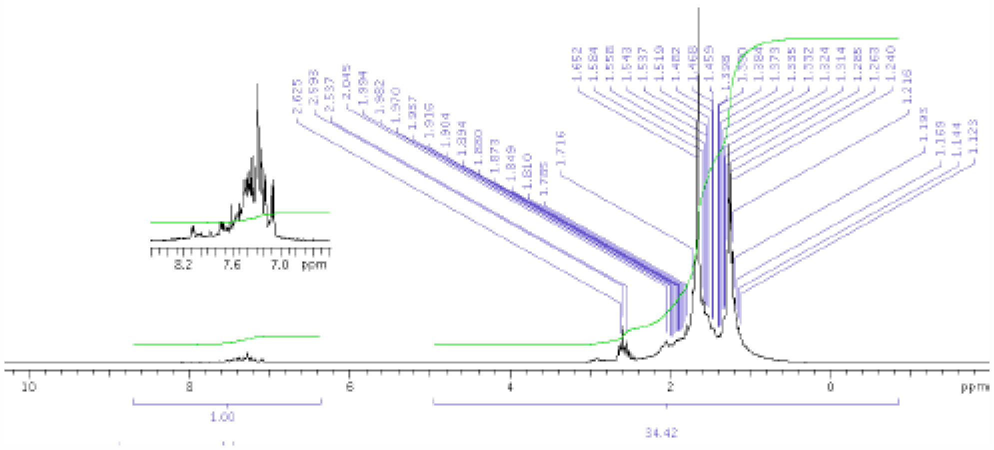


Wavenumber (cm-1)	Vibration assignment
2957	SP2 CH stretch
2928	SP3 antisymm CH stretch
2856	SP3 symm CH stretch
1605	C=C stretch
1458	CH3 antisymm. Deformation/CH2 bend
1377	CH3 bending
675-800	CH out of plane bend

^{1}H NMR

043

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)

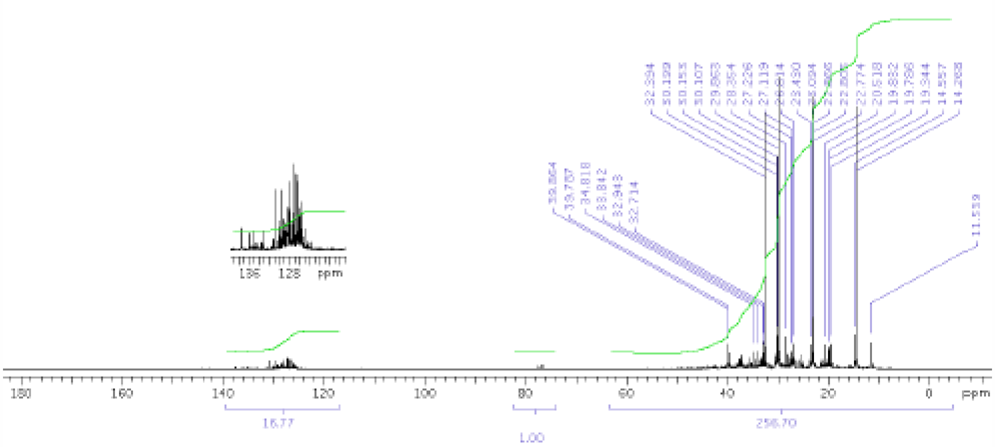


Chemical shift (PPM relative to CDCl3)	Assignment
0.5-1.0	Methyl groups
1.0-1.4	Methylene groups
1.4-2.0	Methine groups
2.0-4.0	Groups adjucent to aromatic
6.7-8.0	Aromatic proton
7.27	Residual CHCl3

^{13}C NMR

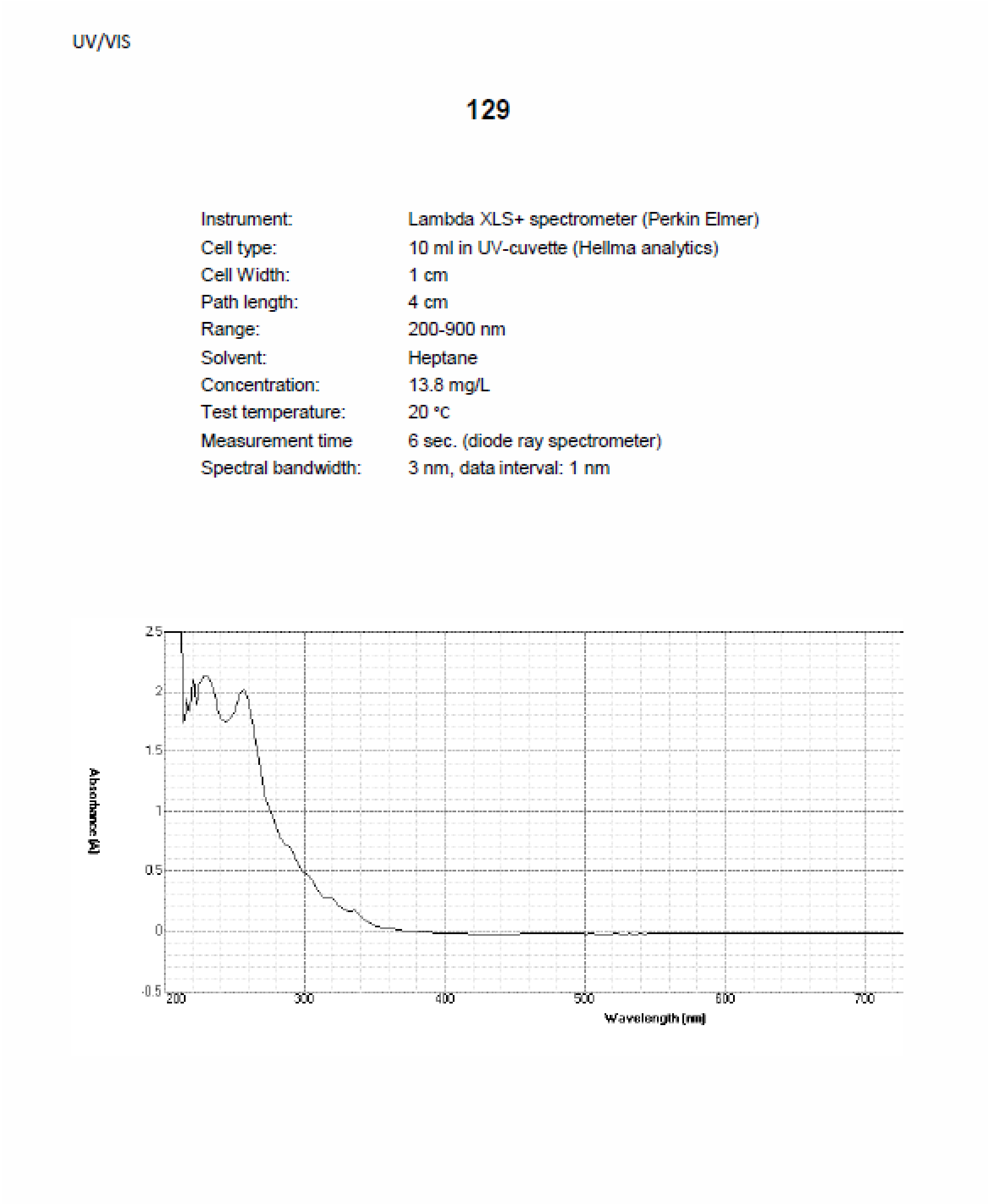
043

Instrument:	Varian Mercury plus 300 NMR spectrometer
Frequency:	^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent:	Deuterated Chloroform, $CDCl_3$
Reference:	Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)



Chemical shift (PPM relative to $CDCl_3$)	Assignment
10-21	Methyl groups
14	CH_3-CH_2-CH_2-
22-23	CH_3-CH_2-CH_2-
26-29	Mid chain methylene groups
32	CH_3-CH_2-CH_2-
30-55	Branched carbons
77	$CDCl_3$
120-150	Aromatic carbons

APPENDIX 11(B) - EXAMPLE OF UV, IR AND NMR SPECTRA (SAMPLE 129 - HFO)



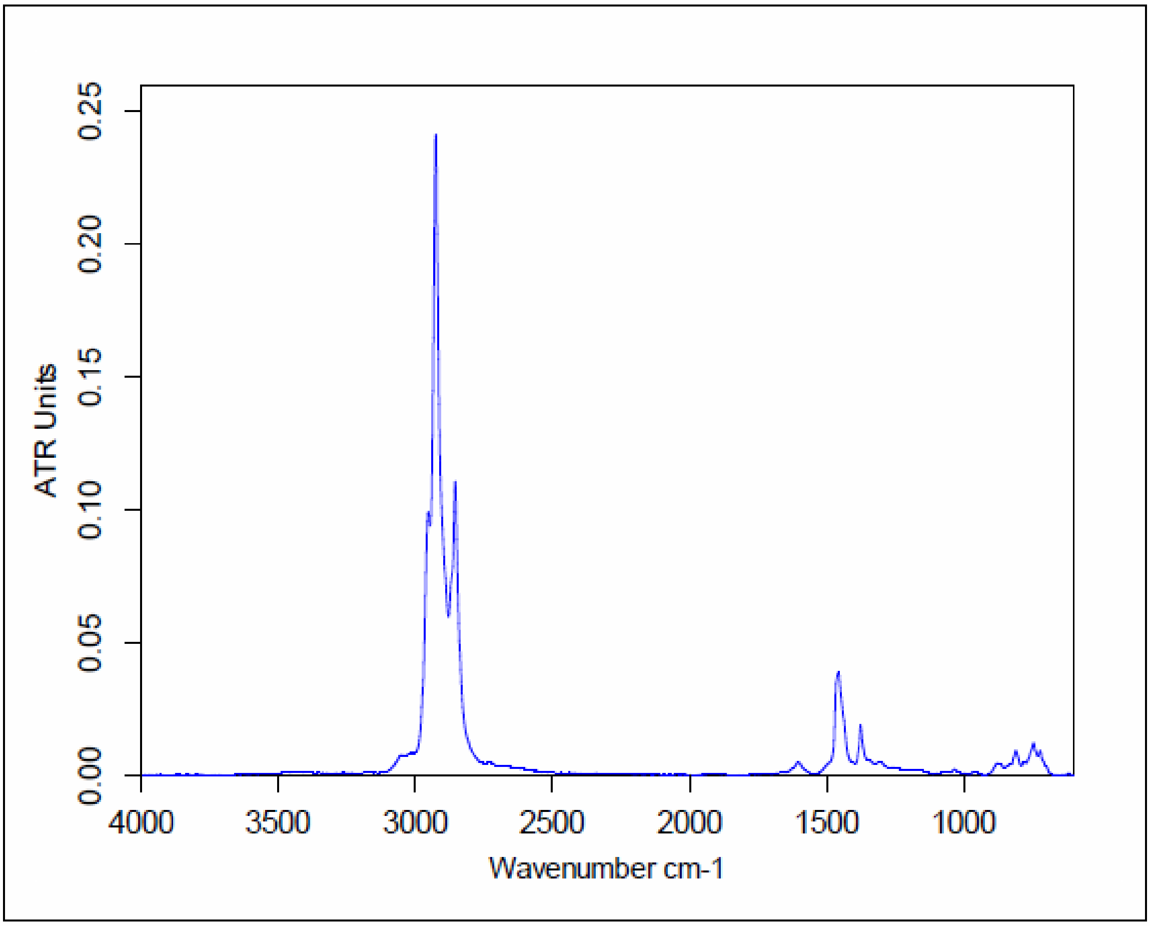
UV/VIS

129

Instrument:	Lambda XLS+ spectrometer (Perkin Elmer)
Cell type:	10 ml in UV-cuvette (Hellma analytics)
Cell Width:	1 cm
Path length:	4 cm
Range:	200-900 nm
Solvent:	Heptane
Concentration:	13.8 mg/L
Test temperature:	20 °C
Measurement time	6 sec. (diode ray spectrometer)
Spectral bandwidth:	3 nm, data interval: 1 nm

129

Instrument: Bruker Tensor 27 FTIR instrument with ATR accessory
Number of scans: 16
Spectral resolution: 4 cm-1

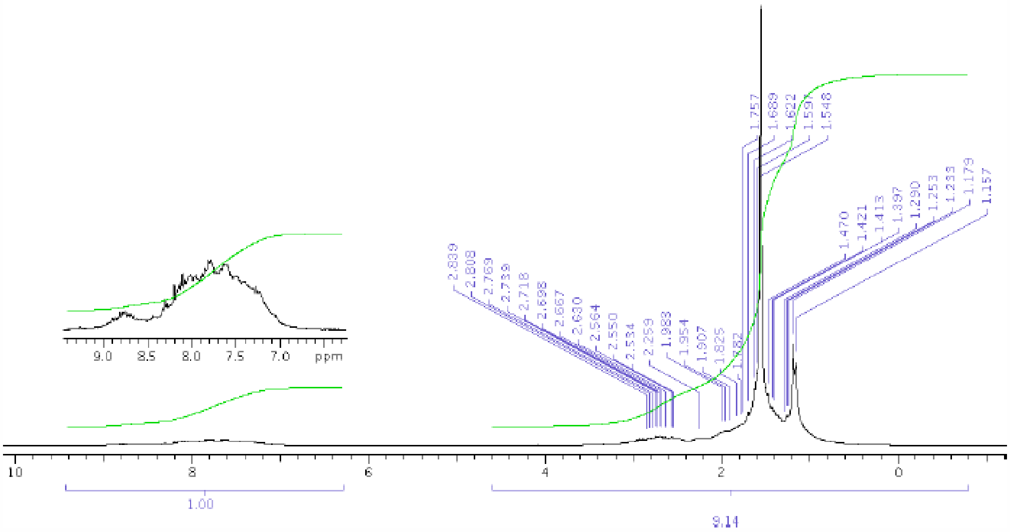


Wavenumber (cm-1)	Vibration assignment
2952	SP2 CH stretch
2927	SP3 antisymm CH stretch
2857	SP3 symm CH stretch
1604	C=C stretch
1460	CH3 antisymm. Deformation/CH2 bend
1378	CH3 bending
675-800	CH out of plane bend

^{1}H NMR

129

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)

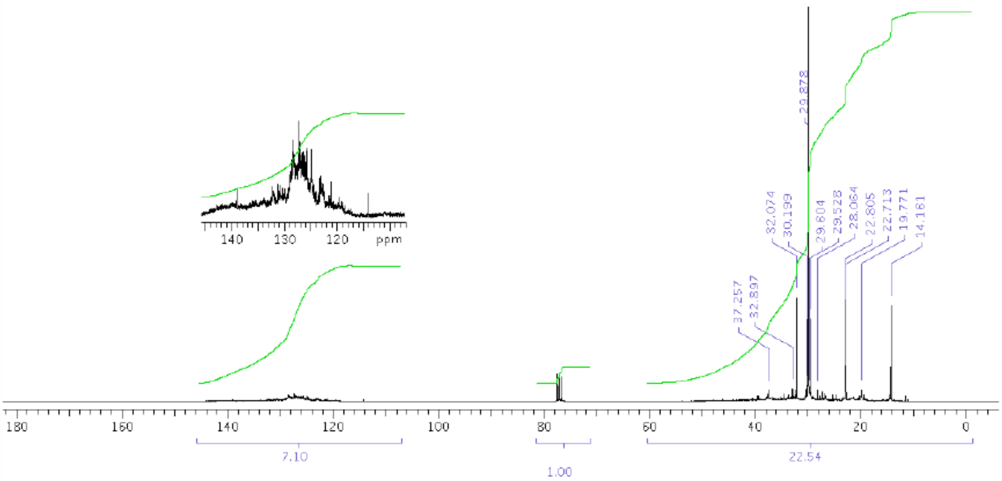


Chemical shift (PPM relative to CDCl3)	Assignment
0.5-1.0	Methyl groups
1.0-1.4	Methylene groups
1.4-2.0	Methine groups
2.0-4.0	Groups adjucent to aromatic
6.7-8.0	Aromatic proton
7.27	Residual CHCl3

^{13}C NMR

129

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)



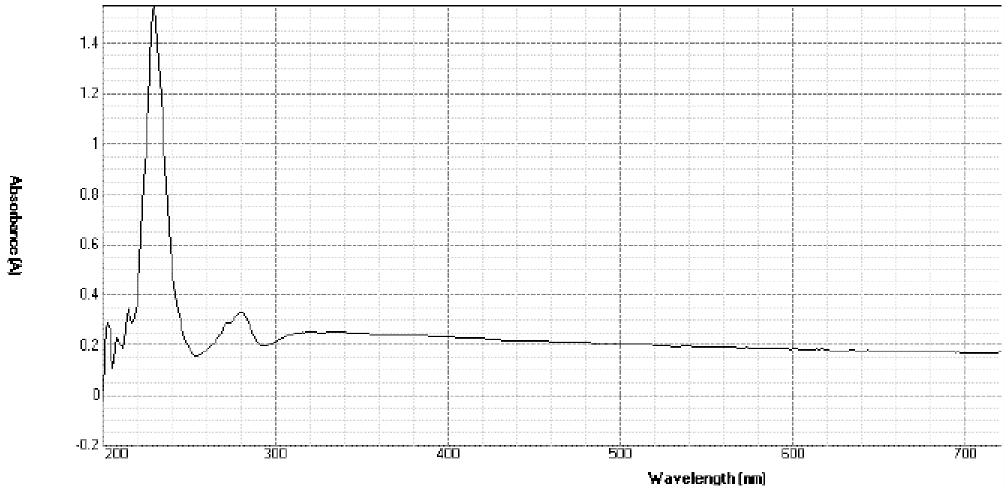
Chemical shift (PPM relative to $CDCl_3$)	Assignment
10-21	Methyl group
14	CH_3-CH_2-CH_2-
22-23	CH_3-CH_2-CH_2-
26-29	Mid chain methylene groups
32	CH_3-CH_2-CH_2-
30-55	Branched carbons
77	$CDCl_3$
120-150	Aromatic carbons

APPENDIX 11(C) - EXAMPLE OF UV, IR AND NMR SPECTRA (SAMPLE 145 - HRBO)

UV/VIS

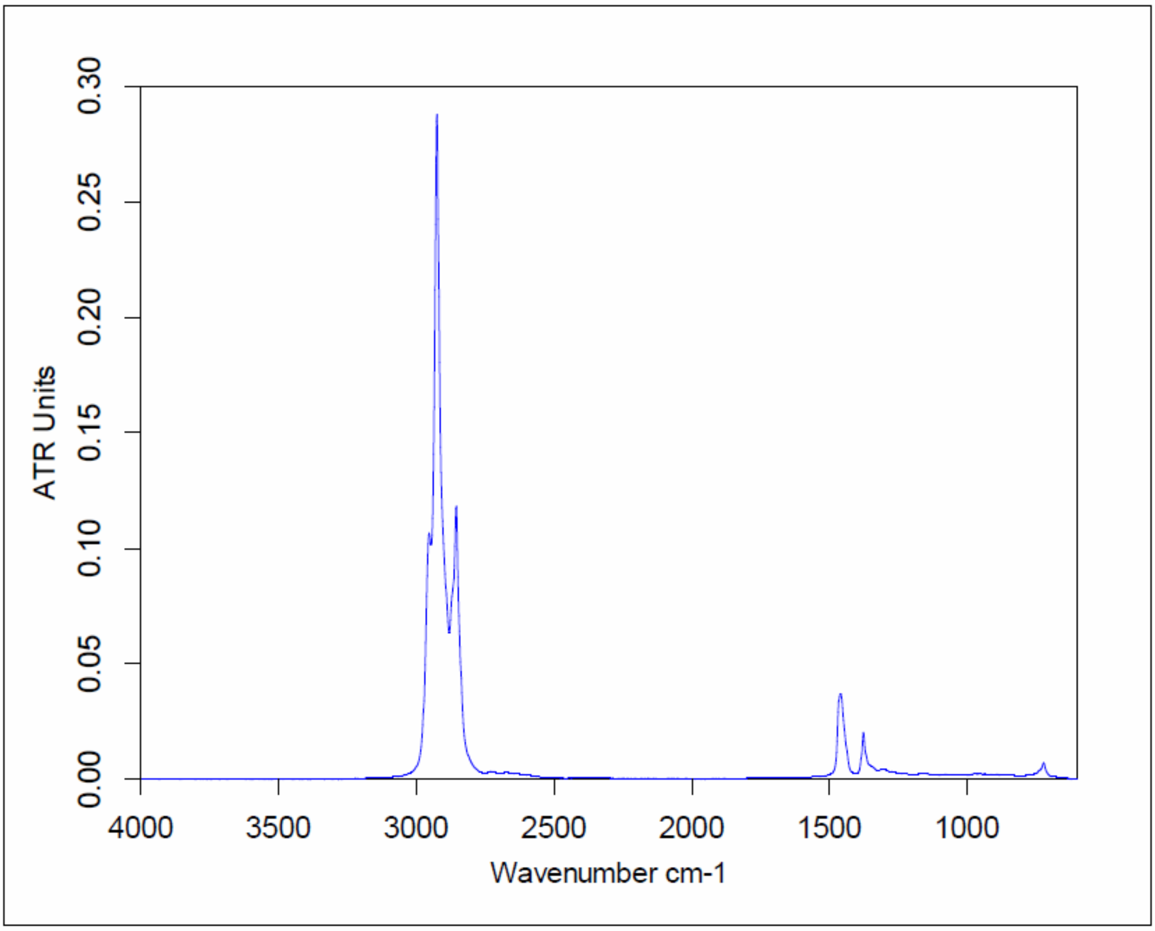
145

Instrument: Lambda XLS+ spectrometer (Perkin Elmer)
Cell type: 10 ml in UV-cuvette (Hellma analytics)
Cell Width: 1 cm
Path length: 4 cm
Range: 200-900 nm
Solvent: none
Concentration: 100% Sample
Test temperature: 20 °c
Measurement time 6 sec. (diode ray spectrometer)
Spectral bandwidth: 3 nm, data interval: 1 nm



145

Instrument:	Bruker Tensor 27 FTIR instrument with ATR accessory
Number of scans:	16
Spectral resolution:	4 cm-1

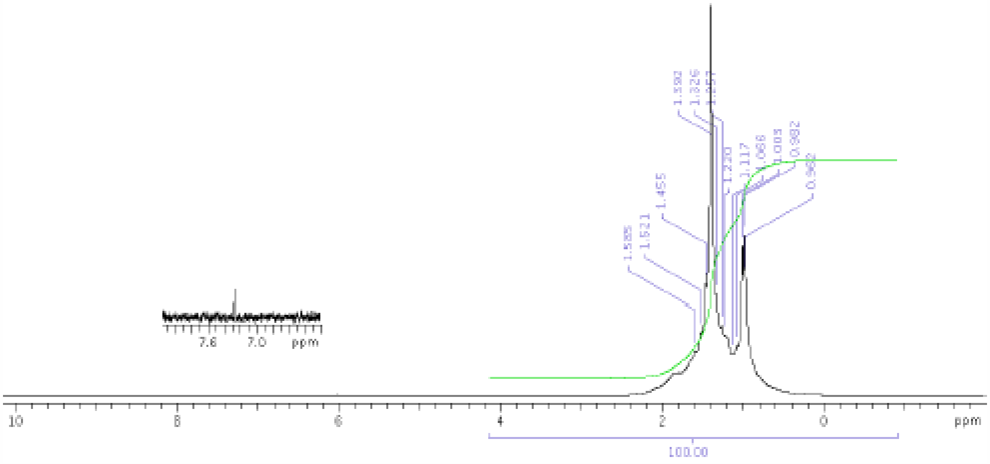


Wavenumber (cm-1)	Vibration assignment
2954	SP2 CH stretch
2928	SP3 antisymm CH stretch
2856	SP3 symm CH stretch
1460	CH3 antisymm. Deformation/CH2 bend
1377	CH3 bending
675-800	CH out of plane bend

^{1}H NMR

145

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)

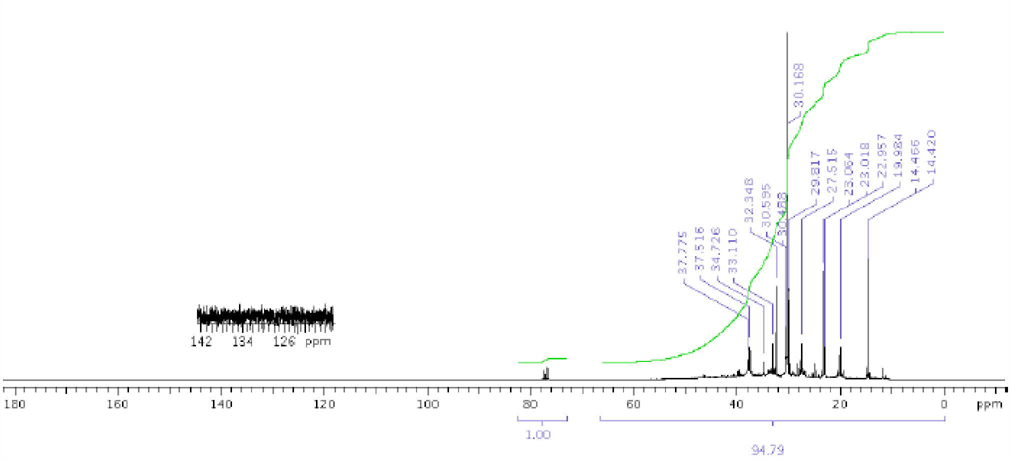


Chemical shift (PPM relative to CDCl3)	Assignment
0.5-1.0	Methyl groups
1.0-1.4	Methylene groups
1.4-2.0	Methine groups
7.27	Residual CHCl3

^{13}C NMR

145

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)

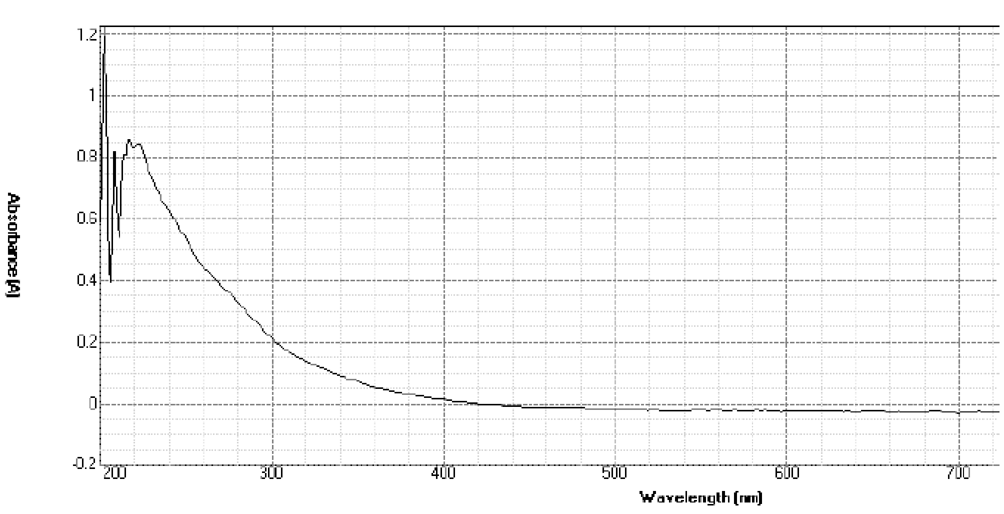


Chemical shift (PPM relative to $CDCl_3$)	Assignment
10-21	Methyl groups
14	CH_3-CH_2-CH_2-
22-23	CH_3-CH_2-CH_2-
26-29	Mid chain methylene groups
32	CH_3-CH_2-CH_2-
30-55	Branched carbons
77	$CDCl_3$

APPENDIX 11(D) - EXAMPLE OF UV, IR AND NMR SPECTRA (SAMPLE X)

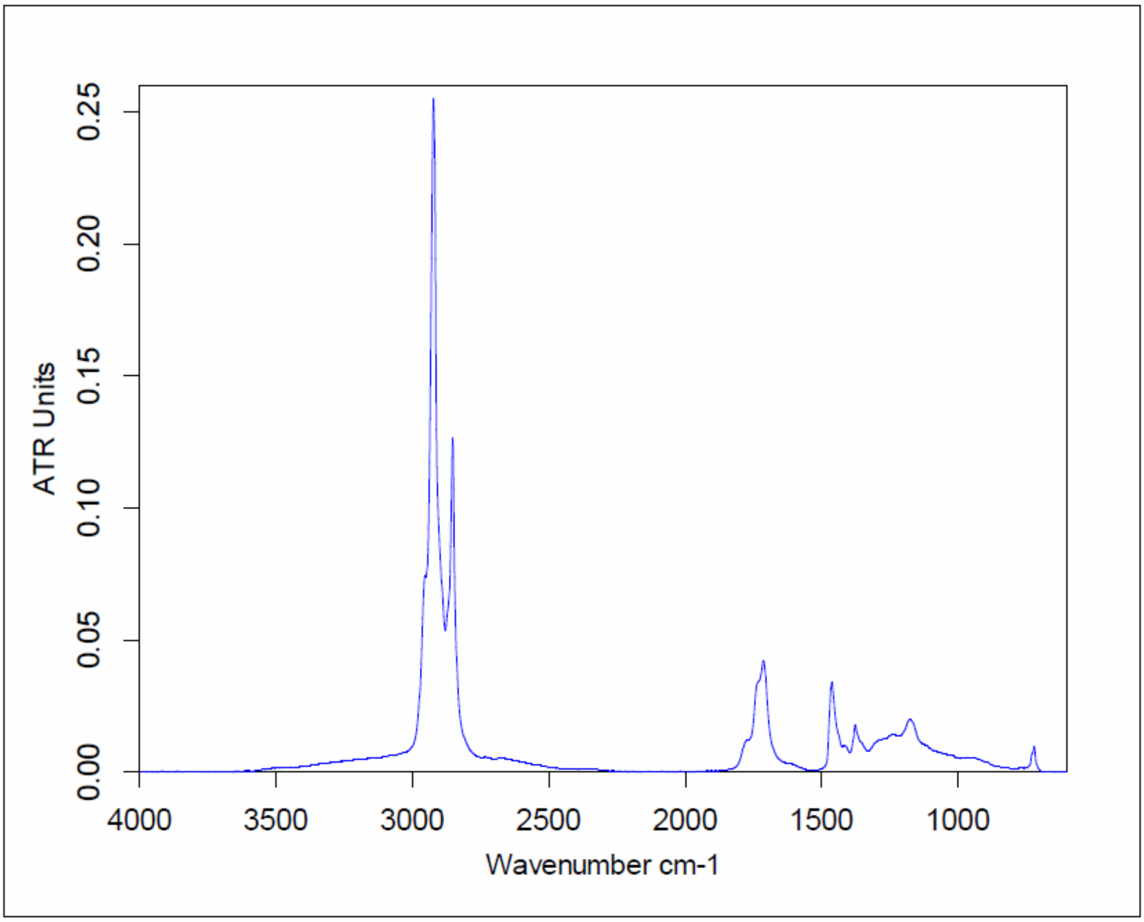
UV/Vis

Instrument:	Lambda XLS+ spectrometer (Perkin Elmer)
Cell type:	10 ml in UV-cuvette (Hellma analytics)
Cell Width:	1 cm
Path length:	4 cm
Range:	200-900 nm
Solvent:	Heptane
Concentration:	49.0 mg/L
Test temperature:	20 °c
Measurement time	6 sec. (diode ray spectrometer)
Spectral bandwidth:	3 nm, data interval: 1 nm



FTIR

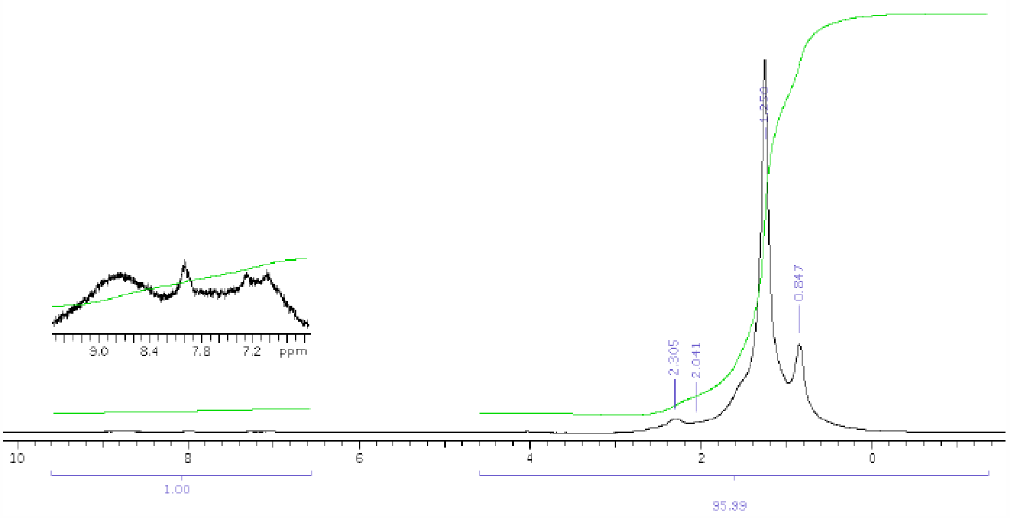
Instrument: Bruker Tensor 27 FTIR instrument
with ATR accessory
Number of scans: 16
Spectral resolution: 4 cm-1



Wavenumber (cm-1)	Vibration assignment
2958	SP2 CH stretch
2918	SP3 antisymm CH stretch
2851	SP3 symm CH stretch
1715	C=O stretch
1604	C=C stretch
1463	CH3 antisymm. Deformation/CH2 bend
1377	CH3 bending
1174	C-O stretch
675-800	CH out of plane bend

^{1}H NMR

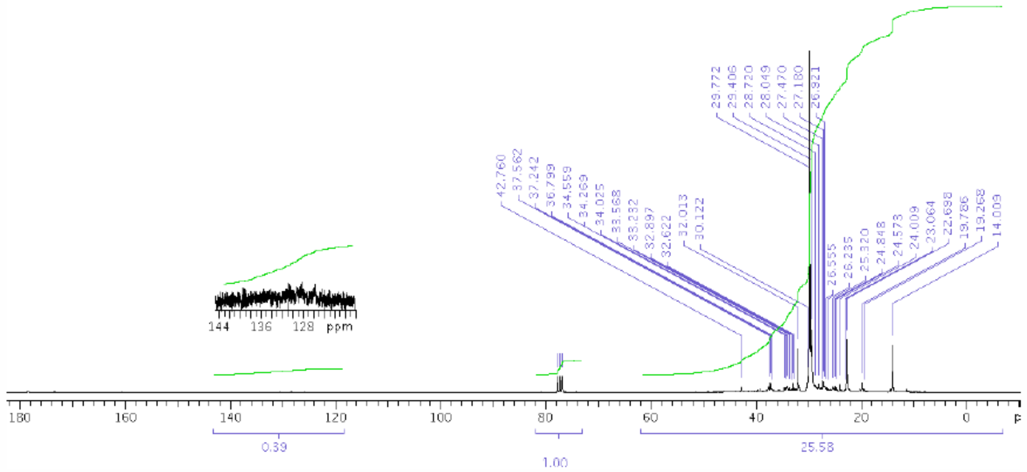
Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)



Chemical shift (PPM relative to CDCl3)	Assignment
0.5-1.0	Methyl groups
1.0-1.4	Methylene groups
1.4-2.0	Methine groups
2.0-4.0	Groups adjucent to aromatic
6.7-8.0	Aromatic proton
7.27	Residual CHCl3

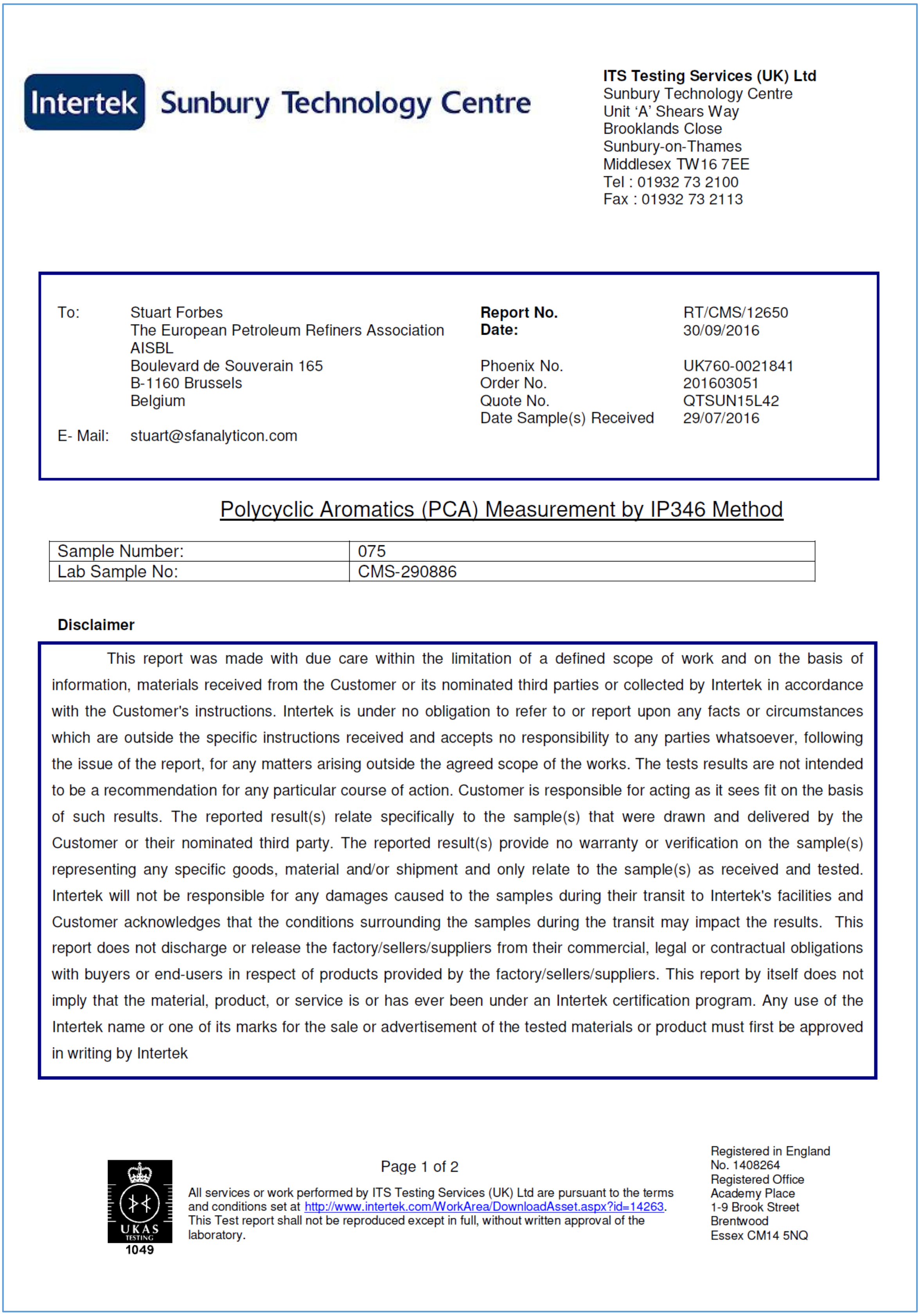
^{13}C NMR

Instrument: Varian Mercury plus 300 NMR spectrometer
Frequency: ^{1}H – 300 MHz; ^{13}C -100 MHz
Solvent: Deuterated Chloroform, $CDCl_3$
Reference: Deuterated Chloroform ($CDCl_3$) (^{1}H chemical shift 2.27 ppm, ^{13}C chemical shift 77 ppm)



Chemical shift (PPM relative to $CDCl_3$)	Assignment
10-21	Methyl group
14	CH_3-CH_2-CH_2-
22-23	CH_3-CH_2-CH_2-
26-29	Mid chain methylene groups
32	CH_3-CH_2-CH_2-
30-55	Branched carbons
77	$CDCl_3$
120-150	Aromatic carbons

APPENDIX 12 – EXAMPLE OF PCA REPORT (SAMPLE 075 - OLBO)



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Report No. RT/CMS/12650
Date: 30/09/2016

Phoenix No. UK760-0021841
Order No. 201603051
Quote No. QTSUN15L42
Date Sample(s) Received 29/07/2016

Polycyclic Aromatics (PCA) Measurement by IP346 Method

Sample Number:	075
Lab Sample No:	CMS-290886

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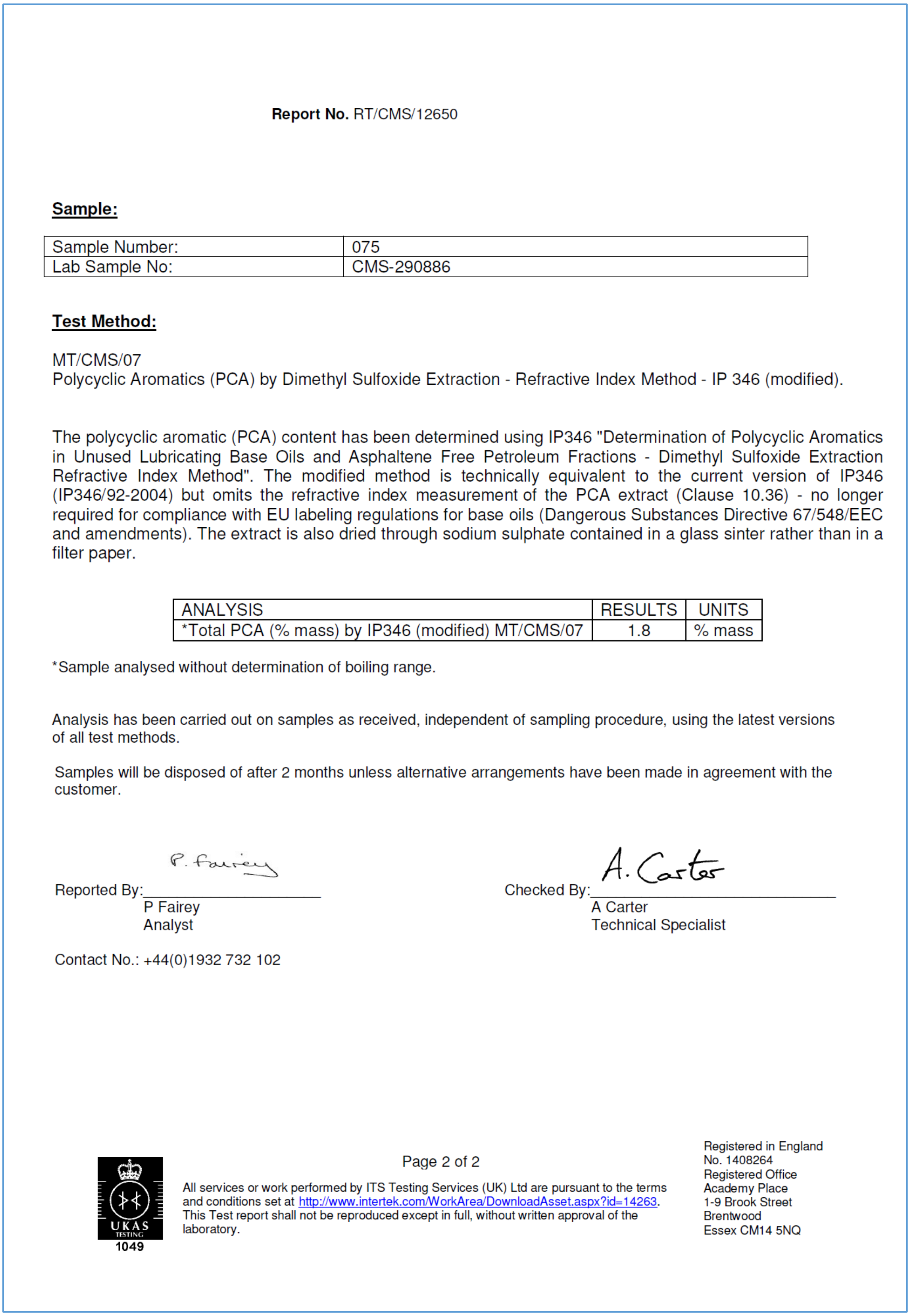

Report No. RT/CMS/12650

Sample:

Sample Number:	075
Lab Sample No:	CMS-290886

Test Method:

MT/CMS/07
Polycyclic Aromatics (PCA) by Dimethyl Sulfoxide Extraction - Refractive Index Method - IP 346 (modified).

The polycyclic aromatic (PCA) content has been determined using IP346 "Determination of Polycyclic Aromatics in Unused Lubricating Base Oils and Asphaltene Free Petroleum Fractions - Dimethyl Sulfoxide Extraction Refractive Index Method". The modified method is technically equivalent to the current version of IP346 (IP346/92-2004) but omits the refractive index measurement of the PCA extract (Clause 10.36) - no longer required for compliance with EU labeling regulations for base oils (Dangerous Substances Directive 67/548/EEC and amendments). The extract is also dried through sodium sulphate contained in a glass sinter rather than in a filter paper.

ANALYSIS	RESULTS	UNITS
*Total PCA (% mass) by IP346 (modified) MT/CMS/07	1.8	% mass

*Sample analysed without determination of boiling range.

Analysis has been carried out on samples as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 2 months unless alternative arrangements have been made in agreement with the customer.

P. Fairey
Reported By:____________________
P Fairey
Analyst

A. Carter
Checked By:____________________
A Carter
Technical Specialist

Contact No.: +44(0)1932 732 102

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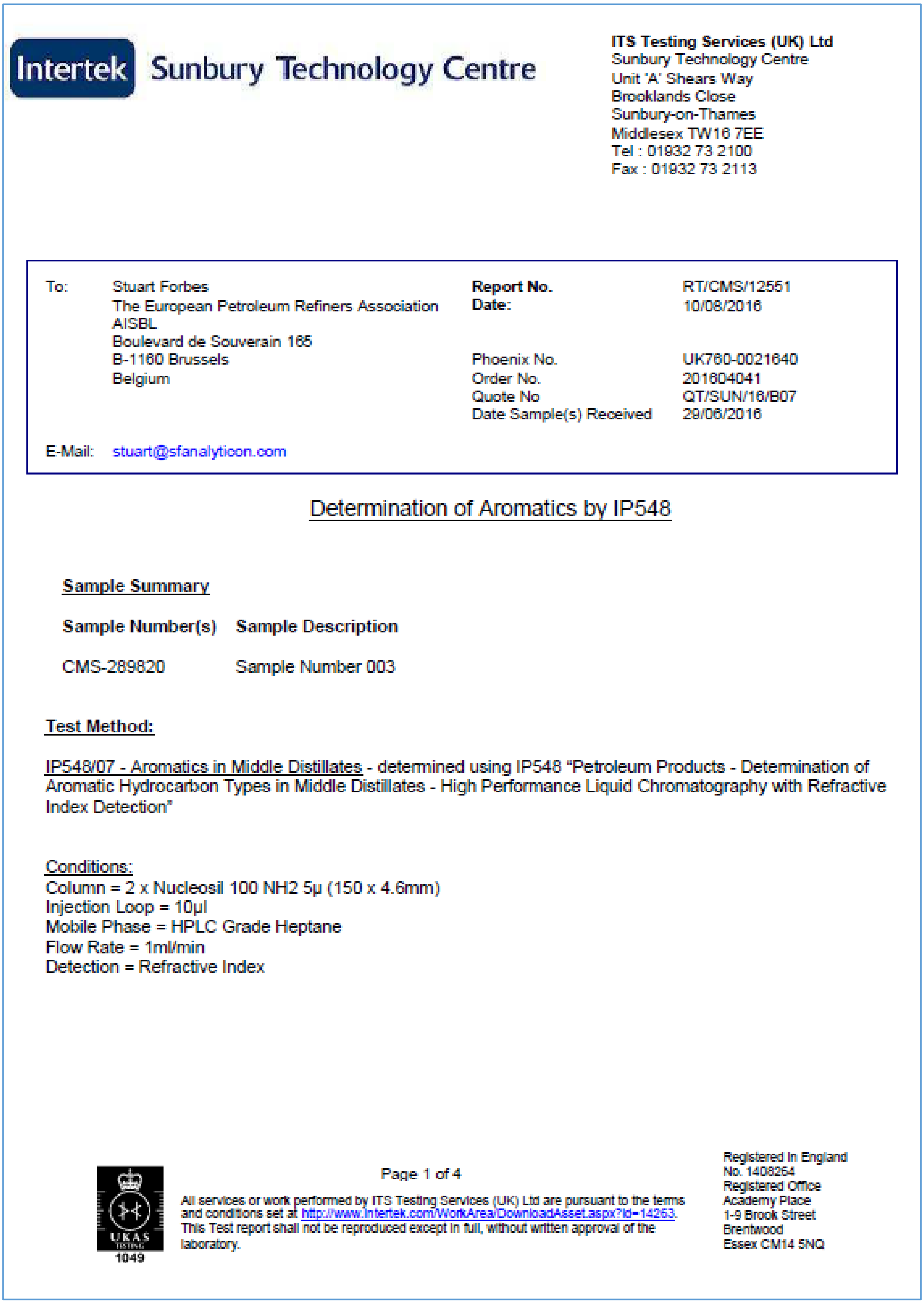
APPENDIX 13 - EXAMPLE OF HPLC REPORT (SAMPLE 003 - CGO)



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Report No.	RT/CMS/12551
Date:	10/08/2016
Phoenix No.	UK760-0021640
Order No.	201604041
Quote No	QT/SUN/16/B07
Date Sample(s) Received	29/06/2016

Determination of Aromatics by IP548

Sample Summary

Sample Number(s)	**Sample Description**
CMS-289820	Sample Number 003

Test Method:

IP548/07 - Aromatics in Middle Distillates - determined using IP548 "Petroleum Products - Determination of Aromatic Hydrocarbon Types in Middle Distillates - High Performance Liquid Chromatography with Refractive Index Detection"

Conditions:
Column = 2 x Nucleosil 100 NH2 5µ (150 x 4.6mm)
Injection Loop = 10µl
Mobile Phase = HPLC Grade Heptane
Flow Rate = 1ml/min
Detection = Refractive Index

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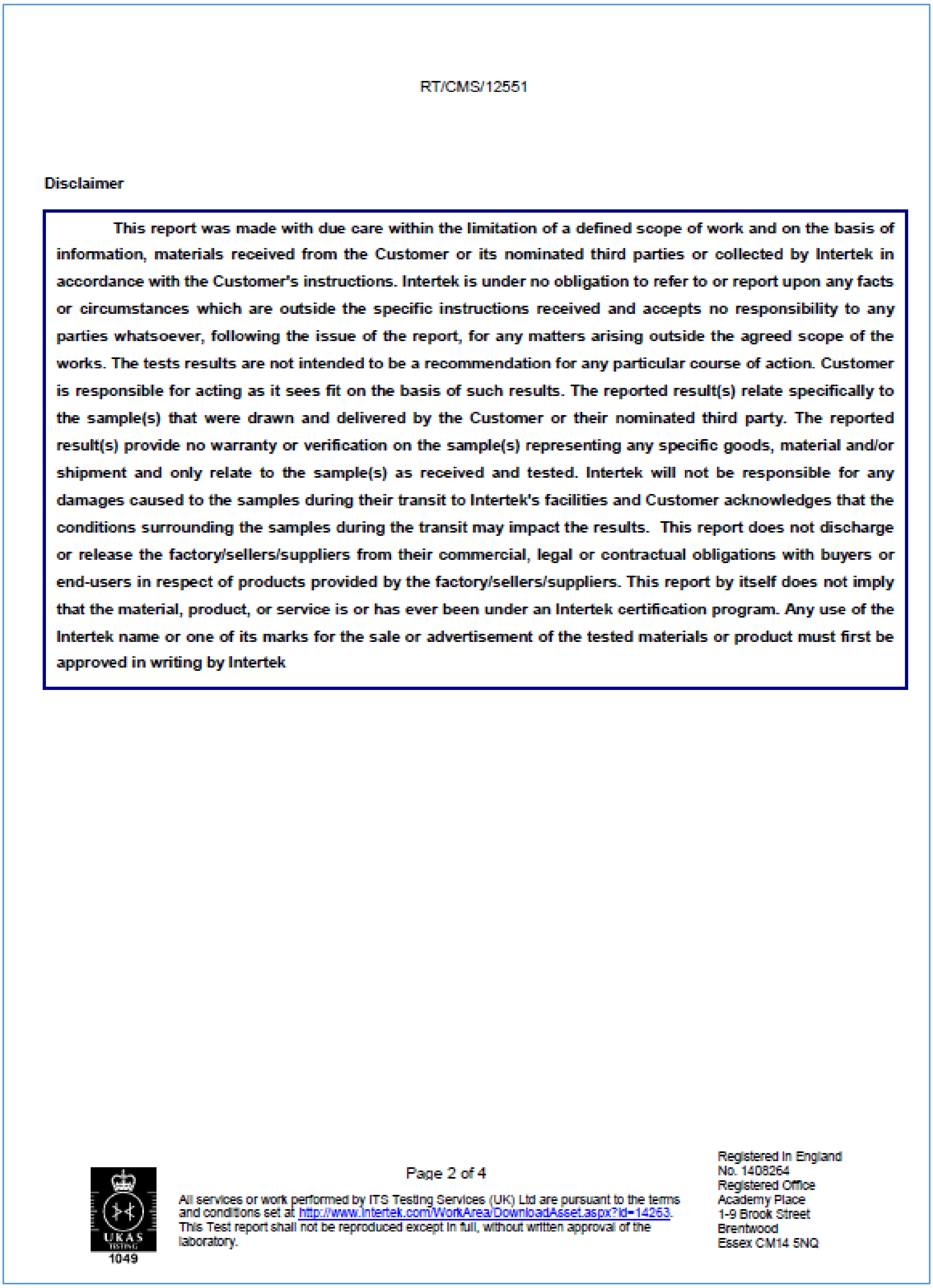

RT/CMS/12551

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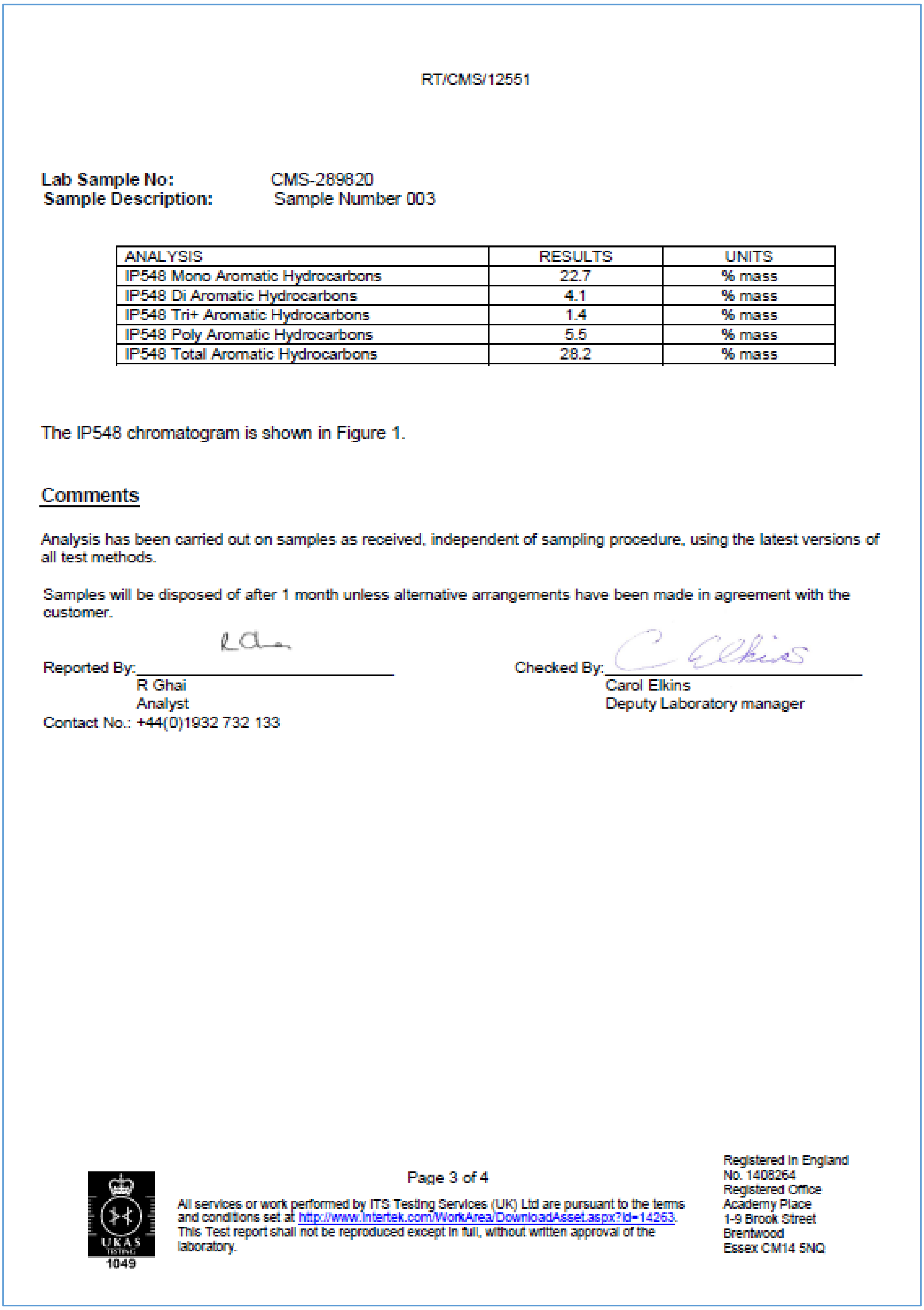

RT/CMS/12551

Lab Sample No: CMS-289820
Sample Description: Sample Number 003

ANALYSIS	RESULTS	UNITS
IP548 Mono Aromatic Hydrocarbons	22.7	% mass
IP548 Di Aromatic Hydrocarbons	4.1	% mass
IP548 Tri+ Aromatic Hydrocarbons	1.4	% mass
IP548 Poly Aromatic Hydrocarbons	5.5	% mass
IP548 Total Aromatic Hydrocarbons	28.2	% mass

The IP548 chromatogram is shown in Figure 1.

Comments

Analysis has been carried out on samples as received, independent of sampling procedure, using the latest versions of all test methods.

Samples will be disposed of after 1 month unless alternative arrangements have been made in agreement with the customer.

Reported By:
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Analyst
Contact No.: +44(0)1932 732 133

Checked By: C Elkins
Carol Elkins
Deputy Laboratory manager

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UKAS TESTING 1049

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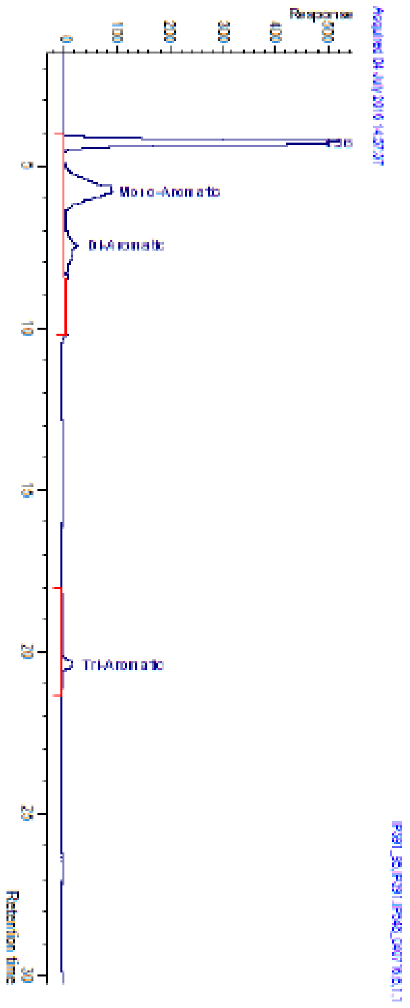
Figure 1 – IP548 Chromatogram from CMS-289820



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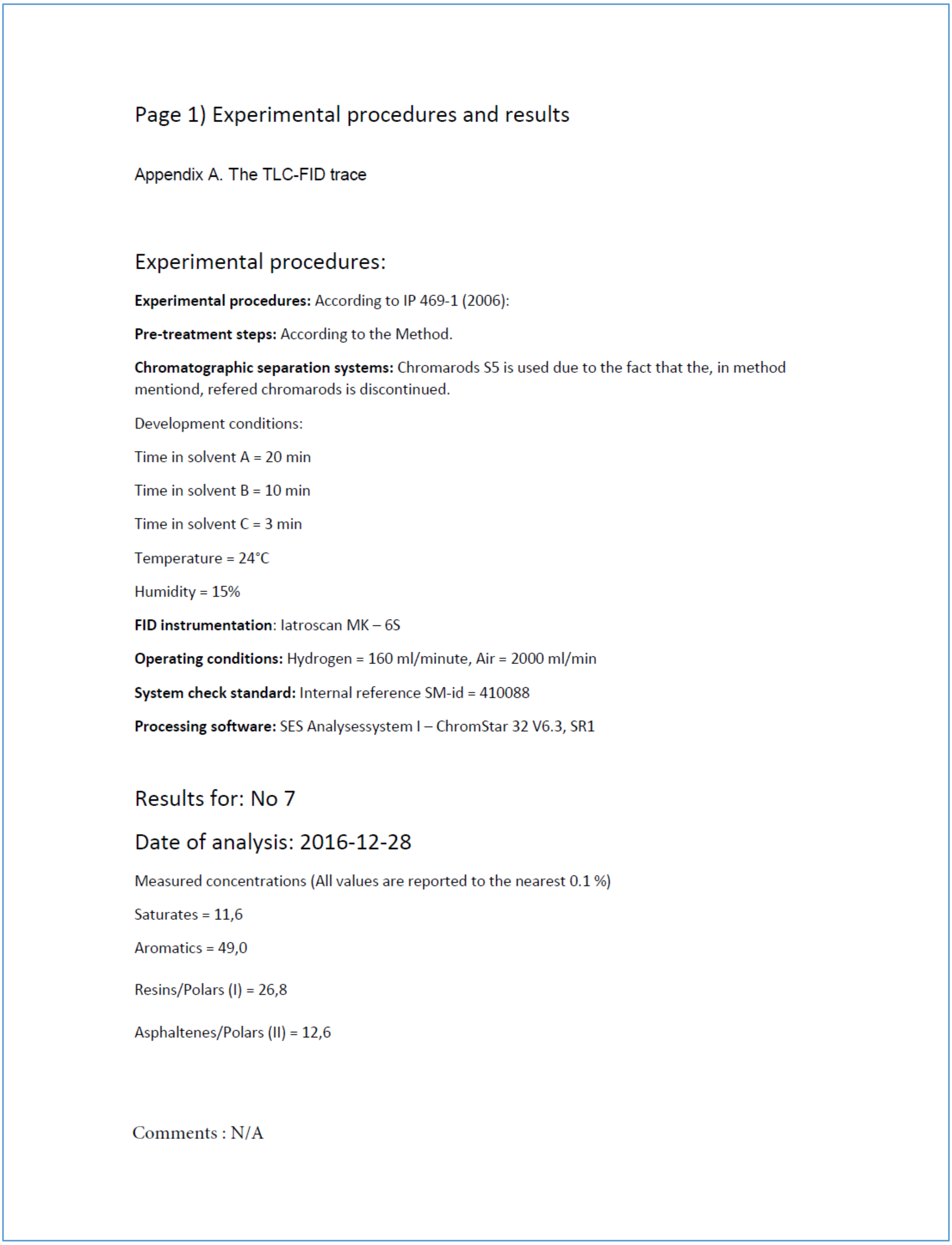
1049

APPENDIX 14 - EXAMPLE OF TLC-FID REPORT (SAMPLE 007 - HFO)



Page 1) Experimental procedures and results

Appendix A. The TLC-FID trace

Experimental procedures:

Experimental procedures: According to IP 469-1 (2006):

Pre-treatment steps: According to the Method.

Chromatographic separation systems: Chromarods S5 is used due to the fact that the, in method mentiond, refered chromarods is discontinued.

Development conditions:

Time in solvent A = 20 min

Time in solvent B = 10 min

Time in solvent C = 3 min

Temperature = 24°C

Humidity = 15%

FID instrumentation: Iatroscan MK – 6S

Operating conditions: Hydrogen = 160 ml/minute, Air = 2000 ml/min

System check standard: Internal reference SM-id = 410088

Processing software: SES Analysessystem I – ChromStar 32 V6.3, SR1

Results for: No 7

Date of analysis: 2016-12-28

Measured concentrations (All values are reported to the nearest 0.1 %)

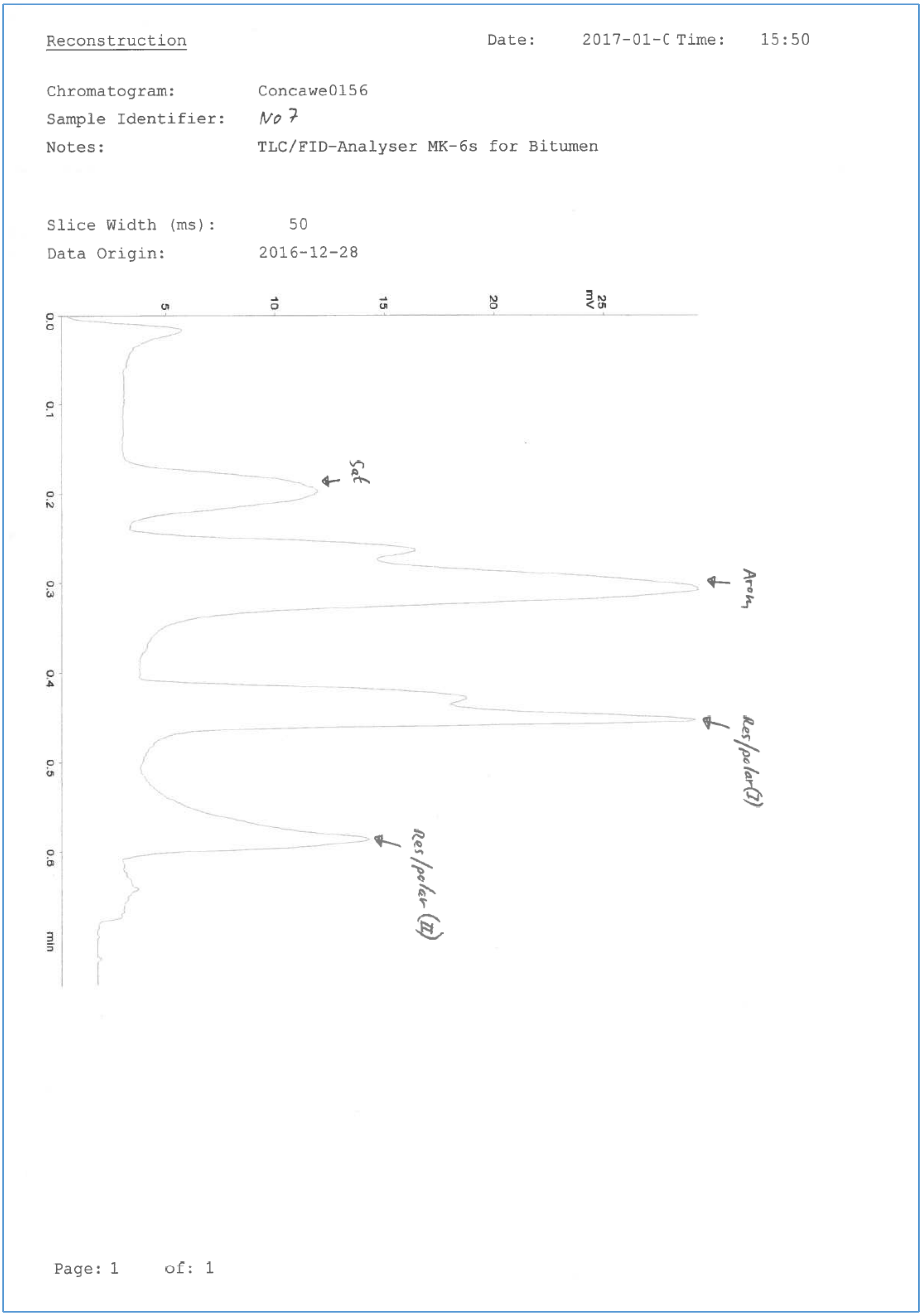
Saturates = 11,6

Aromatics = 49,0

Resins/Polars (I) = 26,8

Asphaltenes/Polars (II) = 12,6

Comments : N/A



Reconstruction

Date: 2017-01- Time: 15:50

Chromatogram: Concawe0156
Sample Identifier: No 7
Notes: TLC/FID-Analyser MK-6s for Bitumen

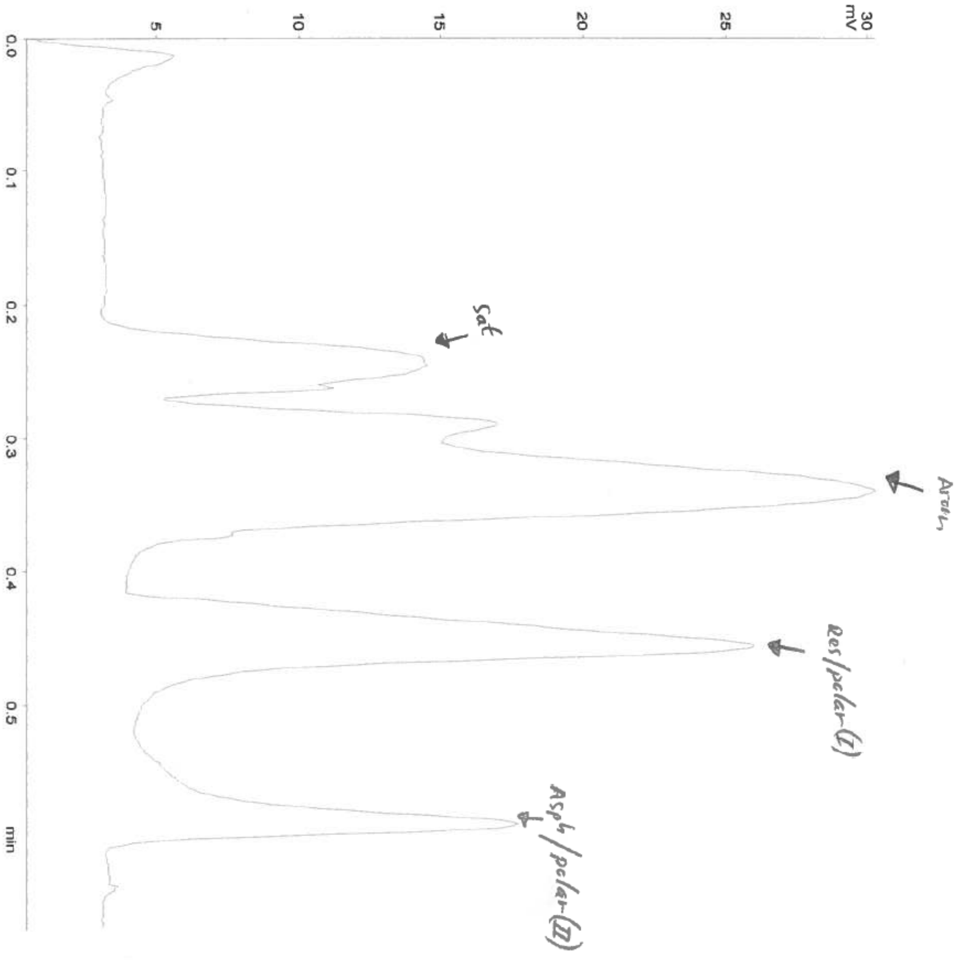
Slice Width (ms): 50
Data Origin: 2016-12-28

Page: 1 of: 1

Reconstruction Date: 2017-01-C Time: 15:49

Chromatogram: Concawe0157
Sample Identifier: No 7
Notes: TLC/FID-Analyser MK-6s for Bitumen

Slice Width (ms): 50
Data Origin: 2016-12-28



Page: 1 of: 1

Reconstruction Date: 2017-01-(Time: 15:49

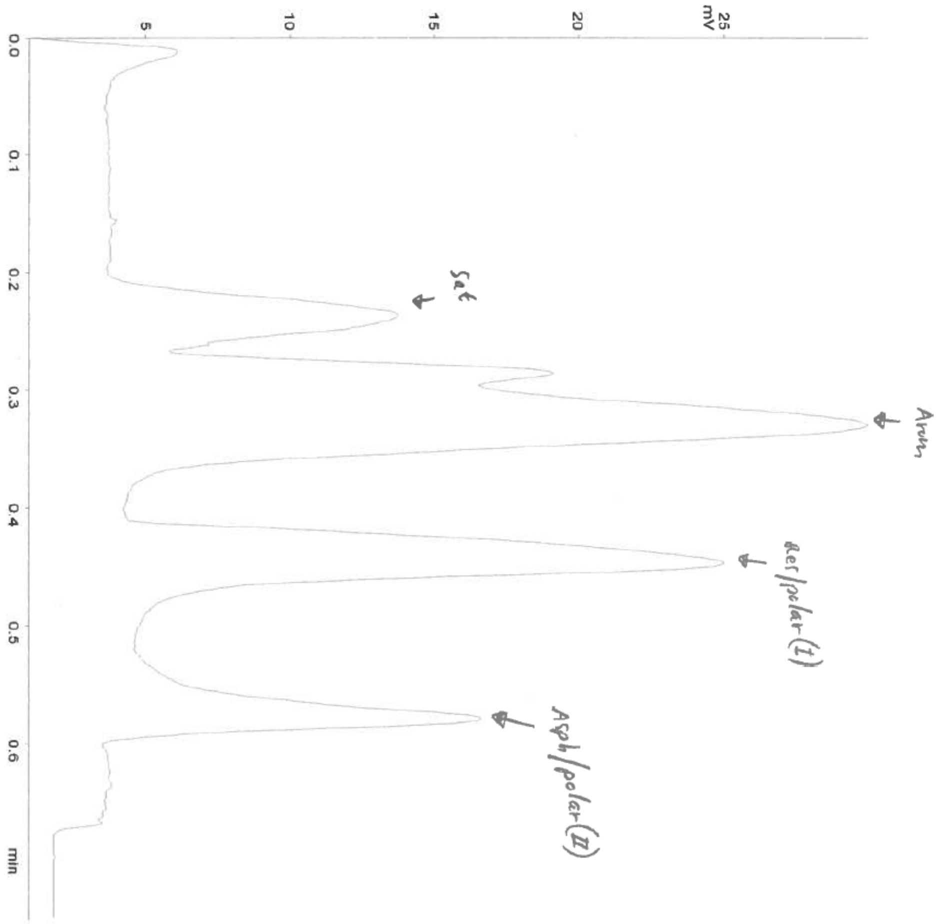
Chromatogram: Concawe0158

Sample Identifier: N07

Notes: TLC/FID-Analyser MK-6s for Bitumen

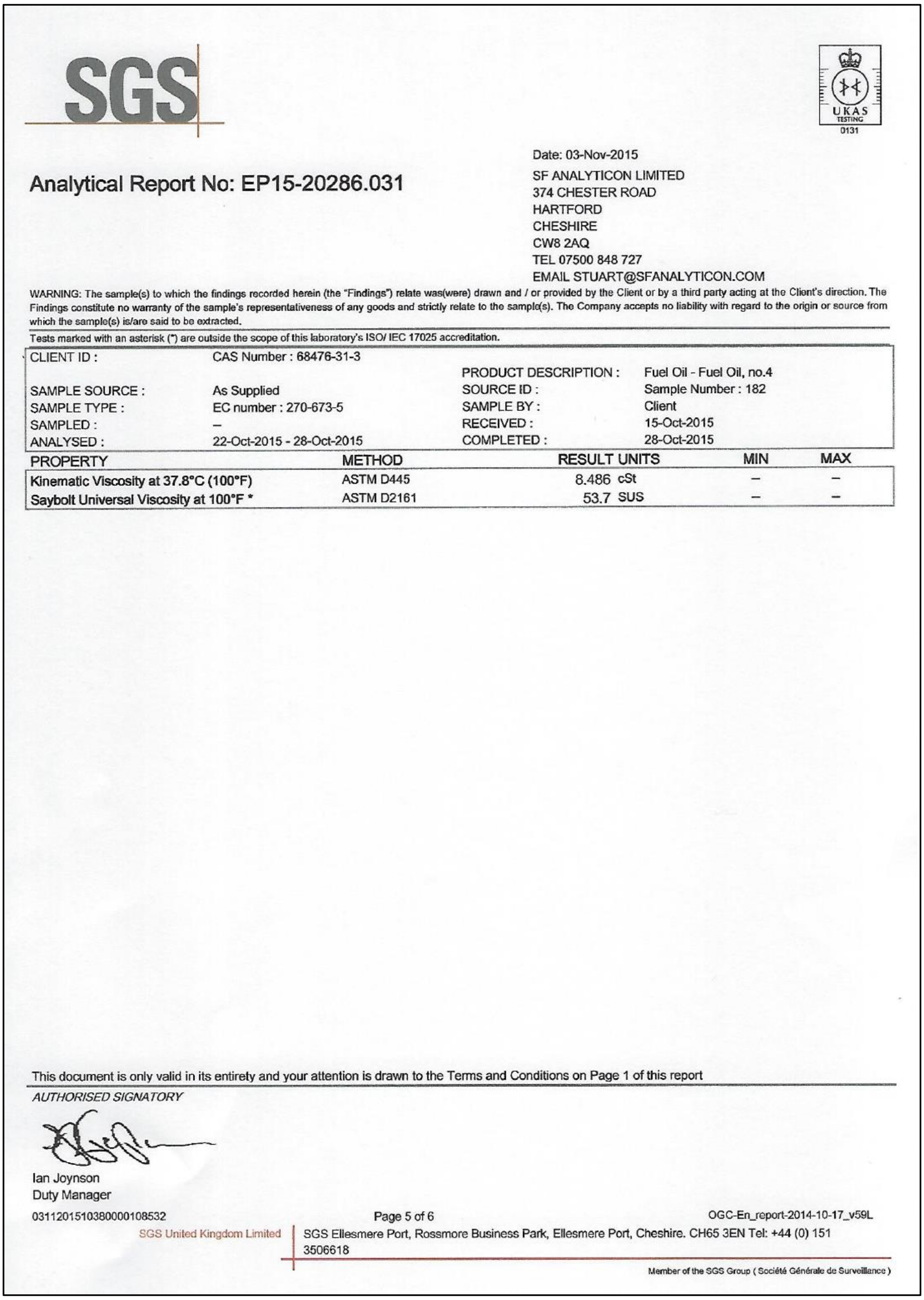
Slice Width (ms): 50

Data Origin: 2016-12-28



Page: 1 of: 1

APPENDIX 15 – EXAMPLE OF VISCOSITY REPORT (SAMPLE 182 - VHGO)



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UKAS TESTING 0131

Date: 03-Nov-2015

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Analytical Report No: EP15-20286.031

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Tests marked with an asterisk (*) are outside the scope of this laboratory's ISO/ IEC 17025 accreditation.

CLIENT ID :	CAS Number : 68476-31-3	PRODUCT DESCRIPTION :	Fuel Oil - Fuel Oil, no.4
SAMPLE SOURCE :	As Supplied	SOURCE ID :	Sample Number : 182
SAMPLE TYPE :	EC number : 270-673-5	SAMPLE BY :	Client
SAMPLED :	–	RECEIVED :	15-Oct-2015
ANALYSED :	22-Oct-2015 - 28-Oct-2015	COMPLETED :	28-Oct-2015

PROPERTY	METHOD	RESULT	UNITS	MIN	MAX
Kinematic Viscosity at 37.8°C (100°F)	ASTM D445	8.486	cSt	–	–
Saybolt Universal Viscosity at 100°F *	ASTM D2161	53.7	SUS	–	–

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AUTHORISED SIGNATORY

Ian Joynson
Duty Manager

0311201510380000108532

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