CONSEIL INTERNATIONAL DES MACHINES A COMBUSTION

INTERNATIONAL COUNCIL ON COMBUSTION ENGINES

RECOMMENDATIONS REGARDING REQUIREMENTS FOR HEAVY FUELS FOR DIESEL ENGINES

AI v ρ T_p

RECOMMANDATIONS CONCERNANT LES EXIGENCES DES FUELS LOURDS POUR MOTEURS DIESEL

CIMAC

Volume 8

1986

CONSEIL INTERNATIONAL DES MACHINES A COMBUSTION

INTERNATIONAL COUNCIL ON COMBUSTION ENGINES

RECOMMENDATIONS REGARDING REQUIREMENTS FOR HEAVY FUELS FOR DIESEL ENGINES

SECOND EDITION*)

RECOMMANDATIONS CONCERNANT LES EXIGENCES DES FUELS LOURDS POUR MOTEURS DIESEL

DEUXIÈME ÉDITION*)

*) The first edition was published in professional magazines in January 1982

*) La première édition a été publiée dans la presse spécialisée en Janvier 1982

This document has been elaborated by the Working Group "Future Fuels" and approved by the Permanent Committee on June 4th, 1985.
Le présent document a été élaboré par le Groupe de Travail «Combustibles Nouveaux» et approuvé par le Comité Permanent le 4me Juin 1985.

Previous publications

1. Recommendations for Internal Combustion Acceptance Test – 1961 *)
   (out of print)
   German version is available

2. Recommendations for Gas Turbine Acceptance Test – 1968
   (English and French version)
   Price: ffrs. 35.00 (plus postage)

3. Recommendations for the Measurement of the Overall Noise of reciprocating Engines – 1970
   (English and French version)
   Price: ffrs. 35.00 (plus postage)

4. Recommendations for SI Units for Diesel Engines and Gas Turbines – 1975
   (English and French version)
   Price: ffrs. 35.00 (plus postage)

5. Recommendations for Supercharged Diesel Engines: *)
   Part I – Engine De-rating on Account of Ambient Conditions
   Part II – Engine Acceptance Tests
   (English version only)
   (not printed)

6. Lexicon on Combustion Engines, Technical Terms of the Internal Combustion Engine and Gas Turbine Industries – 1977
   (in Dutch, English, French, German, Italian, Spanish)
   Price: ffrs. 80.00 (plus postage)

7. Recommendations regarding liability
   – assured properties, publications, fuels
   (English version)
   (French version is available in Paris)
   Price: DM 30,00 or ffrs. 90.00 (incl. postage)

*) Contents of these CIMAC Recommendations is more or less completely adopted in ISO 3046, part 1 – 5

Publications jusqu'à présent

1. Recommendations pour les Essais de Réception des Moteurs à Combustion Interne – 1961 *)
   (épuisé)
   Version allemande est à la disposition

2. Recommendations pour les Essais de Réception des Turbines à Gaz – 1968
   (textes français et anglais)
   Prix: ffrs. 35.00 (port non compris)

3. Recommendations pour la Mesure du Bruit total des Moteurs à Combustion Interne – 1970
   (textes français et anglais)
   Prix: ffrs. 35.00 (port non compris)

4. Recommendations pour l'Emplois des Unités SI dans la Technique des Moteurs Diesel et des Turbines à gaz – 1975
   (textes français et anglais)
   Prix: ffrs. 35.00 (port non compris)

5. Recommendations pour les Moteurs Diesel suralimentés *)
   Part I – Détarage de la puissance en fonction des conditions ambiantes
   Part II – Essais de réception des moteurs
   (version anglaise seulement)
   (pas imprimées)

6. Lexique des termes Techniques des Machines à Combustion, Industrie des Moteurs à Combustion Interne & Industrie des Turbines à Gaz 1977
   (en Allemand, Anglais, Espagnol, Français, Hollandais et Italien)
   Prix: ffrs. 80.00 (port non compris)

7. Recommandation concerning la responsabilité
   – characteristique garanties, publication, combustibles

(Version anglaise)
(version française est à la disposition à Paris)
Prix: DM 30.00 or ffrs. 90.00 (port compris)

*) Contenus des CIMAC Recommandations sont impliquées plus ou moins dans le ISO 3046, part 1 – 5

≈≈≈≈≈≈

These publications can be ordered from the:

Ces publications peuvent être demandées de:

per: Secretary General
Syndicat des Constructeurs de Moteurs à Combustion Interne
10, avenue Hoche,
75382 Paris Cedex 08

Tel. (1) 563.02.00 poste 3565 Telex: FEDEMEC 280900

or from: ou de:

per: German National Committee of CIMAC
Fachgemeinschaft Kraftmaschinen im VDMA
D-6000 Frankfurt/Main 71
Postfach 71 08 64

Tel. (069) 6603351, Telex: 411321, Telefax: 069 6603511

The CIMAC consists of the following member associations:
Le CIMAC est constitué par les associations membres suivantes:

GERMANY – ALLEMAGNE	FACHGEMEINSCHAFT KRAFTMASCHINEN IM VDMA Lyoner Straße 18 – 6000 Frankfurt/Main
AUSTRIA – AUTRICHE	FACHVERBAND DER MASCHINEN- UND STAHL- UND EISENBAUINDUSTRIE ÖSTERREICHS Wiedener Hauptstraße 63, Wien
CHINA – CHINE	THE CHINESE SOCIETY FOR INTERNAL COMBUSTION ENGINES 2500 Jun Gong Road – Shanghai
DENMARK – DANEMARK	JERNETS ARBEJDSGIVER FORENING Nørre Volgade 34 – Copenhagen K
SPAIN – ESPAGNE	GUASCOR S.A. Edificio Guascor – Guascor Building – Zumaya (Gipúzcoa)
U.S.A. – ETATS UNIS	AMERICAN SOCIETY OF MECHANICAL ENGINEERS Diesel and Gas Engine Power Division – Gas Turbine Division 345 East 47 Street – New York, N.Y. 10017
FINLAND – FINLANDE	FINNISH NATIONAL COMMITEE OF CIMCAC Federation of Finnish Metal and Engineering Industries Eteläranta 10 – Helsinki 13
FRANCE – FRANCE	SYNDICAT DES CONSTRUCTEURS DE MOTEURS A COMBUSTION INTERNE 10, avenue Hoche – 75382 Paris CEDEX 08
GREAT BRITAIN – GRANDE-BRETAGNE	BRITISH NATIONAL COMMITTEE OF CIMAC c/o British Engine Group of SMMT Forbes House – Halkin Street – London SW1X 7DS
ITALY – ITALIE	A.N.I.M.A. Piazza Diaz 2 – 201 23 Milano
JAPAN – JAPAN	JAPAN INTERNAL COMBUSTION ENGINE FEDERATION 11–5, 1-Chome, Shinbashi, Minato-ku – Tokyo 105
NORWAY – NORVEGE	A/S NORSK ELEKTRISK & BROWN BOVERI Postboks 1174, Sentrum – Oslo 1
NETHERLANDS – PAYS-BAS	VERENIGING VOOR DE METAAL- EN DE ELEKTROTECHNISCHE INDUSTRIE FME, G.V.M./Bredewater 20 – 2715 CA Zoetermeer Adresse postal: Postbox 190 – 2700 AD Zoetermeer
POLAND – POLOGNE	POLISH SOCIETY OF MECHANICAL ENGINEERS AND TECHNICIANS SIMP, COMBUSTION ENGINE SECTION ul. Swietokrzyska 14 A – 00 – 050 Warszawa
SOVIET UNION – UNION SOVIÉTIQUE	COMMITTEE OF SOVIET EXPERTS ON INTERNAL COMBUSTION ENGINES AND GAS TURBINES (SovCIMAC) Moskovskoje Shosse 25-1, 196158 Leningrad
SWEDEN – SUEDE	FÖRENINGEN SVENSKA TILLVERKARE AV FÖRBRÄNNINGSMASKINER SVENSKA NATIONELLA CIMAC-KOMMITTEN Västerbergsgatan 3 – 431 39 Molndal
SWITZERLAND – SUISSE	SOCIETE SUISSE DES CONSTRUCTEURS DE MACHINES Kirchenweg 4 – Zürich – Case Postale

Members of the Working Group "Future Fuels"

Les membres de la Group de Travail «Combustibles Nouveaux»

Dr. Syassen

Mr. Fiedler

GERMANY – ALLEMAGNE

Dr. O. Syassen, Chairman
Motoren-Werke Mannheim AG, Mannheim

Mr. H. Fiedler, Coordinator
Krupp MaK Maschinenbau GmbH, Kiel

AUSTRIA – AUTRICHE

Dr. S. Pachernegg
AVL, Graz

DENMARK – DANEMARK

Mr. O. Grøne
M.A.N. – B & W Diesel A/S, Copenhagen

FINLAND – FINLANDE

Mr. D. Paro
Oy Wärtsilä AB, Vaasa

FRANCE – FRANCE

Mr. M. Bontour
Société d'Etudes de Machines Thermiques, Saint Denis Cedex 1

GREAT BRITAIN – GRANDE BRETAGNE

Mr. H. Niven
Ricardo Consulting Engineers, Shoreham-by-Sea, Sussex

ITALY – ITALIE

Dr. U. Agnelli
Grandi Motori Trieste, Trieste

JAPAN – JAPON

Dr. H. Fujita
Japan Internal Combustion Engine Federation, Tokyo 105

NORWAY – NORVEGE

Mr. B. Isdal
A.S. Bergens Mekaniske Verksteder

Mr. O. M. Hallen
I. M. Skaugen A/S, Oslo

NETHERLANDS – PAYS-BAS

Mr. J. H. Wesselo
Stork Werkspoor Diesel B.V., Amsterdam

POLAND – POLOGNE

Mr. Z. Poklewski-Koziell
Z.P.M. H. Cegielski, Obrwsoik, Poznan

SWEDEN – SUEDE

Prof. L. Collin
Chalmers University of Technology, Göteborg 5

Mr. S. Eriksson
Alfa Laval, Tumba

SWITZERLAND – SUISSE

Mr. H. Konrad
Sulzer Brothers Ltd, Winterthur

Experts as special guests:

Mr. J.J.H. Sundermeyer, Chevron
Mr. R.E. Williams, Shell International
Mr. K.M. Chomse, Shell International
Mr. D. Royle, D.N.V.

Foreword of the president

Mr. French

In 1978 Dr. Syassen of MWM Mannheim/Germany proposed the formation of a CIMAC-Working Group "Future Fuels". This proposal was submitted by Mr. A. Schiff from the German National Committee to the Permanent Committee. It was accepted and Dr. Syassen agreed to act as Chairman of the Group.
The objective of this Group was to consider the expected operational and technical problems of future residual fuel supplied worldwide, and to influence and support International Standardization work in such a way, that the results would be acceptable to engine-operators and engine-manufacturers alike.
As a result of this work, which was originally completed in 1983, the ideas of the CIMAC-Working Group were introduced into the draft of the future ISO-Standards.
In addition to this, also in 1983 "CIMAC-Recommendations of Requirements for Intermediate Fuels" have been published in several technical magazines.
During the two years following publication, the table in a more or less complete form was introduced into engine builders' specifications, but comments from different parties (shipowners, major oil companies, etc.) indicated that in the interests of a wide-spread distribution of the CIMAC recommendations, a different, more official publication was needed.
Consequently it was decided to revise the Recommendations with respect to new guide-lines as follows:
- CIMAC is not a standards institute, so has the possibility of filling the gap not covered by standards.
- The Recommendations should be formulated for practical use.
- The Recommendations should be revised in the light of changing situations and should give information about latest developments with quick response to changing situations. They should not be withdrawn after final publications of ISO-Standards.
- The Recommendations should be issued as a CIMAC Working Group Publication.

The new draft has been finished in May 1985 and hopefully will have a widespread acceptance not only in the marine field but also in all other applications of diesel engines burning residual fuels.
I would like to thank the Working Group for this excellent work. They not only successfully coped with quite controversal technical problems, but also succeeded in determining correctly the technical position of all three parties, operators, fuel suppliers and engine-builders of the engine building industry in a most economic and co-operative way.

C. C.J. French

Introduction du president

En 1978, le Docteur Syassen de la Société MWM Mannheim (en Allemagne) proposa la création d'un groupe de travail CIMAC «Nouveaux Combustibles». M.A. Schiff, membre du Comité National Allemand, soumit cette proposition au Comité Permanent. Celle-ci fut approuvée et le Docteur Syassen accepta d'assurer la présidence du Groupe.
L'objectif de ce Groupe était d'étudier les problèmes techniques et de fonctionnement liés à l'approvisionnement des nouveaux combustibles résiduels dans le monde, d'influencer et de soutenir les travaux du Comité de Normalisation International afin de parvenir à des résultats acceptables aussi bien par les utilisateurs des moteurs que par les constructeurs.
L'aboutissement de ces travaux, achevés en 1983, fut marqué par la reprise des idées du groupe de travail CIMAC dans le projet des nouvelles normes ISO.
De plus en 1983, les recommandations CIMAC concernant les exigen ces pour les combustibles intermédiaires furent publiées dans plusieurs revues techniques.

Au cours des deux années qui suivirent cette publication, le tableau fut introduit, sous une forme plus ou moins complète, dans les spécifications des constructeurs de moteurs. Toutefois, des commentaires émanant de tous côtés (armateurs, principales compagnies pétrolières, etc...) ont montré que, dans l'intérêt d'élargir la diffusion des recommandations du CIMAC, une publication différente, plus officielle, était indispensable.
En conséquence, il fut décidé de réviser les recommandations en regard des nouvelles directives énumérées ci-après:

- le CIMAC n'est pas un Institut de Normalisation. Aussi a-t-il la possibilité de couvrir les domaines non protégés par les Normes.
- les recommandations doivent répondre à une utilisation pratique.
- les recommandations doivent être révisées en fonction des évolutions et doivent donner des informations sur les derniers développements.
- elles ne doivent pas être retirées après publication des normes ISO définitives.
- les recommandations doivent être présentées comme des publications d'un groupe de travail CIMAC.

Le nouveau projet a été achevé en Mai 1985 et nous espérons qu'il sera largement adopté non seulement dans le domaine des applications marines mais encore dans toutes les autres applications des moteurs Diesel brûlant des combustibles résiduels.
Je voudrais remercier les membres du groupe de travail pour l'excellent travail fourni. Ils ont, non seulement, traité avec succès les problèmes techniques largement controversés, mais sont aussi parvenus à définir correctement la position technique de l'ensemble des trois parties concernées, les utilisateurs, les fournisseurs de combustibles et les constructeurs de moteurs, dans un sens plus économique et plus coopératif.

C. C.J. French

CONTENTS

SOMMAIRE

1. Historical background

The decreasing quality of residual fuels, experienced worldwide in the past few years, and the economic incentive to operate marine diesel engines virtually exclusively with low grade fuels, have resulted in an increasing demand for an internationally accepted fuel specification.

The first action to obtain a new marine fuel standard was taken by the British Standards Institution (BSI) and resulted in the BS-MA 100 (1982) standard. Simultaneously, the CIMAC working group on 'Future Fuels' began work on a separate recommendation for requirements for a full range of residual fuels for diesel engines. This recommendation was published in the professional magazines, in January 1982.

The BSI then introduced a proposal for a new international standard (DIS) to be approved by the International Organisation for Standardization (ISO). The work of the ISO is well in progress, a draft proposal has been established and probably in late 1985 or in 1986 the final ISO standard will be issued. The ISO specification closely resembles the CIMAC recommendation of 1982.

The aim of the BSI specification was that all grades would be available worldwide and thus it defines those fuels that are currently on the market or will be in the near future. Limits were imposed only on those parameters considered to be essential for modern marine diesel engines and for proper fuel treatment on board.

CIMAC, predominantly representing engine manufacturers and users, have a different perspective, and therefore introduced a number of 'higher quality' grades to cope with the demands of:

- Existing ships which may not be equipped with the fuel storage and treatment systems required for modern fuels.
- Older engine designs and smaller modern engines for which satisfactory operation is only possible if certain limits are respected.

As ISO does not recognize international availability as a criterion for fuel quality, the 'higher quality' CIMAC grades could be introduced within the ISO specification. As a result the ISO specification closely resembles the CIMAC recommendation of 1982.

2. Scope

Also the present second edition of the CIMAC recommendation will resemble the draft ISO specification. The difference between the two requirements lies essentially in the nature of the two organisations. ISO, as an official standards organisation, can only specify characteristics for which test procedures exist. Also the formal procedures, involving many national standards institutions, impede quick and flexible reactions to new developments. It is the intention of CIMAC to fill this resultant gap by issuing requirements that are, as far as possible, similar to the ISO specifications, but which can be published earlier, and further by adding some means of specifying fuel characteristics that cannot yet be specified in the ISO tables. The latter particularly applies to catalyst fines, stability and ignition quality.

The scope of the CIMAC recommendation covers all residual diesel engine fuels that are of economic importance today or probably will be in the future. Distillate fuels are excluded because the necessity for improved specifications is not apparent.

Although the CIMAC recommendation resulted from discussions about marine fuel specifications, there is no reason why it cannot be applied to both land-based and marine diesel engines. In both cases the requirements apply to the time and place of custody transfer.

The recommendation is intended for use by the engine manufacturers in their manuals and thus will contribute to the harmonisation of the specifications. It is, however, issued by the central CIMAC Secretariat and so is available for engine users, the oil industry, etc., and hopefully will find wide application.

The recommendation will be periodically reviewed and revised if necessary.

3. Relation between CIMAC and ISO Residual Fuel Oil Specifications

In connection with section 2, it is the intention that no part of the specification of a CIMAC grade will conflict with the corresponding ISO grade. In this edition of the CIMAC specification, this aim has been fulfilled with respect to the **draft** standard ISO/DIS 8217. Changes will be considered if the final ISO standard differs from the draft.

As a consequence, every CIMAC grade is fundamentally an ISO grade with some **additional** requirements. The only exception is CIMAC K 55.

There are comparable CIMAC grades for all ISO grades excluding RML 35, 45 and 55, which have no limit for carbon residue.

The resulting differences are:

1. CIMAC K 35, K 45 and K 55 have, in contradiction to ISO-F-RMK 35, 45 and 55, a density limit of 1010 kg/m^3 (15°C) (see section 7.1.)
2. In all grades aluminium is limited to 30 mg/kg (see section 7.2.)
3. All CIMAC grades are fuels which can be expected to produce no excessive sludge during normal fuel treatment (see section 7.3.).

4. Sampling

Sampling of the fuels should be carried out in accordance with the procedure given in ISO 3170. Additional suggestions about sampling are presented in 'CIMAC Recommendations for Heavy Fuel Treatment'.

5. General Requirements

The fuels shall be homogenous mixtures of hydrocarbons derived from petroleum. This shall not preclude the incorporation of small amounts of additives intended to improve some aspect of performance. The fuel shall not contain contaminants from non-petroleum sources (such as inorganic acids and alkalines) other than those particularly mentioned in the specification.

6. Specific Requirements in Accordance with ISO

The properties of the fuels shall not exceed the maximum values nor be less than the minimum values set out in the tables. The values shall be obtained by the following test methods:

Density:
ISO 3675 – Crude petroleum and liquid petroleum products – Laboratory determination of density or relative density. Hydrometer method. This method is to be used at a temperature between 50 °C and 60 °C and the hydrometer readings converted to 15 °C using table 53B referred to in ISO 91/1.

Kinematic viscosity:
ISO 3104 – Petroleum products – Transparent and opaque liquids – Determination of kinematic viscosity and calculation of dynamic viscosity.

Flash point:
ISO 2719 – Petroleum products – Determination of flash point. Penski-Martens closed cup method.

Pour point:
ISO 3016 – Petroleum oils – Determination of pour point.

Carbon residue:
ISO 6615 – Petroleum products – Determination of carbon residue – Conradson method.

Ash:
ISO 6245 – Petroleum products – Determination of ash.

Water:
ISO 3733 – Petroleum products and bituminous materials – Determination of water – Distillation method.

Sulphur:
IP 336/81.

Vanadium:
DIN 51790 part 2 (July 1978).

7. Specific Requirements in Addition to ISO

7.1 Density

ISO grades RMK35 and RMK45 are not limited in density. CIMAC, however, recognizes the need to remove water from fuels of densities higher than the currently accepted limit of 991 kg/m^3. Thus CIMAC K 35, 45 and 55 include a density limit of 1010 kg/m^3 reflecting the current state of the art in water separation.

7.2 Catalyst fines

The first and most common method to limit the amount of catalyst fines by means of maximum 30 ppm aluminium, has been maintained and constitutes a definite part of the specification. Measuring of the aluminium content by means of I.P. method nr. 363/83 is recommended.

The definition of the amount of catalyst fines by means of aluminium content is open to criticism on the following grounds:

1. The ratio between aluminium and total catalyst fines, though typically about 5, has been found to vary between about 3 and 8. To cope with this problem one alternative is to calculate the catalyst content from the measured Al and Si contents, using the relationship 1.89 Al + 2.14 Si.
   Another alternative is the ASTM 4484 centrifuge method which determines to total amount of inorganic particles excluding iron oxydes. Whether or not any of these methods correlate with engine wear better than Al has yet to be proven.
2. The amount of wear may also relate to the particle size distribution and to the hardness of these particles. However, these characteristics cannot readily be controlled by a fuel specification.

Discussion on alternatives to an aluminium specification is far from finished and will be continued by CIMAC. Despite its shortcomings, however, experience over the last few years has demonstrated that the introduction of a 30 ppm Al limit has led to a general worldwide decrease in the level of abrasive particles in marine fuels and for this reason CIMAC wishes to maintain the 30 mg/kg max. Al limit for the time being. The figure presumes that the fuel treatment plant is designed and operated to acceptable standards.

7.3 Cleanliness, stability and compatibility

All residual fuels contain a small amount of sediment or sludge, which may include finely divided particles of agglomerated asphaltenes, coke or adventitious materials. At the low sediment levels normally present in bunker fuels, no difficulty will be experienced. If the sediment level becomes too high, however, extreme difficulty may be experienced in fuel handling systems.

Sediment or sludge occurs in three different fuel properties. They are:

- **Cleanliness:**
  Cleanliness of a fuel is defined as the amount of sediment measured in a filtration test. An I.P. method is under development for measuring the 'total existent sediment'.
- **Stability**
  Fuels are unstable when the amount of sediment or sludge increases significantly with time, or as a result of heating in storage or during transport. The stability of bunker fuels may be predicted by accelerated ageing test methods which simulate the natural process.
- **Compatibility**
  Fuels are incompatible if a mixture of two or more fuels produces a blend which is unstable. An assessment of the compatibility of fuels thus involves the prediction of the stability of the blend.

Since compatibility is not a property of the delivered fuel alone, it can never be part of the specification. There are ways of predicting compatibility of two fuels in advance by determining specific parameters of both fuels, but it will be a long time before these parameters will be supplied with every fuel before bunkering.

A good indication of the compatibility of two fuels can be obtained by means of any stability test, applied to a mixture of the fuels in the intended ratio, but samples of both fuels are generally not available in advance. The risk of compatibility problems should therefore be avoided as much as possible by appropriate design of the fuel treatment installation (see 'CIMAC Recommendations for Heavy Fuel Treatment').

Cleanliness and stability, however, should be part of the requirements to avoid the risk of excessive sludge during fuel treatment as far as possible. Since sludge generally is a combination of sediment due to insufficient cleanliness and to lack of stability, the resulting 'total sediment after ageing' could be the parameter to be limited. There is, however, until now, no internationally agreed test method available and thus no single definition can be used in the table. Responsible fuel suppliers, however, check the supplied fuel with their in-house test methods such that no excessive sludge will be produced if the supplied fuel is used in a normal, well functioning fuel treatment installation.

Only if this is the case will a fuel be considered to be in accordance with the CIMAC requirements.

Several in-house test methods are available and may be applied to ensure adequate fuel quality. They are:

Test type	Designation	Limit	Particulars
Existent sediment	Mobil MM 1006	0,3% v/v	Centrifuge method
Existent sediment	Exxon AMS 79–007	0,15% m/m	Applies hot filtration. Gives a reasonable indication for fuel stability due to pre-history of most fuels as supplied in practice.
Stability	Shell SMS 2696	0,10% m/m	Applies hot filtration, but also includes an ageing step. Without that step the method determines existing sediment.
Compatibility	Mobil MM 1292	0,3% v/v	Refers to mixing of residual and distillate fuels and thus can only be used for the blending of fuels.

The spot-test according to ASTM D 2781 also predicts the compatibility of blended residual and distillate fuel. Due to the ease of using this test on board, modified spot tests are used to judge the cleanliness of residual fuels, or their stability, if an ageing test is added, or their compatibility by checking the stability after mixing. Experience, however, has indicated that compatible fuels occasionally fail to pass this test due to deficiencies in the test procedure.
Modified spot tests for residuals are under development.

7.4 Ignition quality

The establishment of a good test method to determine the ignition quality of a residual fuel is perhaps a more difficult task than to determine any other important fuel parameter. As a result, it is not yet possible to include any requirement regarding ignition properties in the present recommendation.
Recently, oil company laboratories have recognized a relation between the density of the fuel (at a given viscosity) and its aromaticity, and also between the ignition properties of the fuel and its aromaticity. As a consequence, density and viscosity together **roughly** determine ignition quality. There is, however, an appreciable spread of the measured data with the effect that the ignition properties of the fuel cannot definitely be derived from density and viscosity.
The most useful lesson from experience is that fuels with a higher than average density may cause ignition trouble at part load operation. In practice this has only occurred with thin fuels (for example 40 or 80 cSt at 50 °C and density 980 or 990 kg/m^3). Also, experience has shown that with particular engine types air inlet heating resulted in satisfactory operation with a fuel that could not be used without this provision.
Recent investigations by several research institutes show that a modified test derived from the early methods according to DIN 51748 or ASTM E659-78 gives values for the auto ignition temperatures (AIT) that also correlate with the ignition properties in engines. It appears that the correlation is closer than that with the density – viscosity relationship. The reliability of the method is confirmed by an apparent correlation with the cetane number for distillate fuels. The results are being published in CIMAC paper D 120, Oslo 1985.

8. Precision and the Interpretation of Test Results

The majority of methods, specified in Clauses 6 and 7, contain a statement of the precision (repeatability and reproduceability) to be expected from each test. Attention is drawn to ISO 4259 – 'Petroleum products. Determination and application of precision data in relation to methods of test'. This procedure shall be used in cases of dispute.

9. Principal Grades

The development of residual fuel standards for so many grades has been criticized for understandable reasons. To counter this criticism to some extent, CIMAC has nominated some fuels that should preferably be specified by engine manufacturers.
They have been selected for the following reasons:

1.a. For existing ships without heating around all fuel pipes, and operating under winter conditions, a lower pour point than 24 ° or 30 °C is necessary. For those ships, the appropriate fuel grade that would normally be bunkered can only be used if this fuel can be supplied with a lower than standard value for the pour point (about 0 °C). The only standard grade complying with this aim is CIMAC A 10, which may be better than required in other aspects.

1.b. For the engines of small ships, or the auxiliary engines of larger ships, CIMAC A 10 may be useful, being the best possible residual fuel at a lower price than marine diesel fuel.

2. The properties of CIMAC E 25 roughly represent the quality level with which experience has been obtained in many ships over many years.
   In all cases where reasons exist to limit vanadium or carbon residue levels in residual fuels, this is a relatively safe choice.

3. CIMAC G 35 and H 35 have a specification still allowing their use in conventional centrifuging systems (densities not higher than 991 kg/m^3). G 35 is the most common fuel on the market place but there are places, and there will be more in future, where only H 35 is available.

4. Fuels with viscosities of max. 45 or 55 cSt at 100 °C will rarely be available with a maximum density of 991 kg/m^3. Therefore, they will be mostly offered as K-grades, which have a density limit of 1 010 kg/l. They represent the fuels as produced with the most modern conversion methods and require a novel centrifuging system for the higher density. Ships with these systems mostly will also have adequate heating for viscosities up to 55 cSt at 100 °C.
   The density limit will cause that the fuel will be 55 cSt only in exceptional cases, rather 45 cSt and often even 35 cSt. Therefore, the "worst" of the principal grades actually is the group of the three grades CIMAC K 35, K 45 and K 55. The market share of this group is still small but may very well increase in future.

Requirements (June 1986) for heavy fuels for diesel engines (as bunkered)

Principal grades

Designation:				CIMAC A 10	CIMAC B 10	CIMAC C 10	CIMAC D 15	CIMAC E 25	CIMAC F 25	CIMAC G 35	CIMAC H 35	CIMAC K 35	CIMAC H 45	CIMAC K 45	CIMAC H 55	CIMAC K 55
Draft ISO-F-				RMA 10	RMB 10	RMC 10	RMD 15	RME 25	RMF 25	RMG 35	RMH 35	RMK 35	RMH 45	RMK 45	RMH 55	—
Related to **BS MA 100 1982**				M 4 3)		—	M 5	—	M 6	—	M 7	—	M 8	—	M 9	—
Characteristic	Dim.	Limit	**CIMAC 1982**	4	3	2	5	6	7	—	8	9	10	11	12	—
Density at 15 °C	kg/m³	max		975	991		991	991		991		1010	991	1010	991	1010
Kinematic viscosity at 100 °C	cSt 1)	max		10			15	25		35			45		55	
Flash point	°C	min		60			60	60		60			60		60	
Pour point 2)	°C	max		0 6	24		30	30		30			30		30	
Carbon Residue (Conradson)	% (m/m)	max		10		14	14	15	20	18	22		22		22	
Ash	% (m/m)	max		0.10			0.10	0.10	0.15	0.15	0.20		0.20		0.20	
Water	% (V/V)	max		0.50			0.80	1.0		1.0			1.0		1.0	
Sulphur	% (m/m)	max		3.5			4.0	5.0		5.0			5.0		5.0	
Vanadium	mg/kg	max		150		300	350	200	500	300	600		600		600	
Aluminium	mg/kg	max		30			30	30		30			30		30	
Total sediment after ageing		max		4)			4)	4)		4)			4)		4)	

1) Approximate equivalent viscosities (for information only):

Kinematic viscosity (cSt) at	100°C		10	15	25	35	45	55
Kinematic viscosity (cSt) at	80°C		15	25	45	75	100	130
Kinematic viscosity (cSt) at	50°C		40	80	180	380	500	700
Kinematic viscosity (cSt) at	40°C	14						
Sec. Redwood I at	100°F	80	300	600	1500	3500	5000	7000

2) Where relevant: upper value winter quality
bottom value summer quality

3) Carbon Residue 12 for BS grade M4

4) No standard test method agreed. Fuel shall not cause excessive sludge during normal fuel treatmant, see 7.3 for in-house test methods.