SOUTH AUSTRALIA DEPARTMENT OF MINES AND ENERGY



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SPECIFICATIONS OF PETROLEUM PRODUCTS A REVIEW

AMDEL REPORT NO. 1568 (SADME DOCKET REFERENCE DME 103/85)

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SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY

ANDEL Report

NO. 1568

REVIEW OF PETROLEUM PRODUCTS SPECIFICATIONS VOLUME I

Ву

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FOREWORD

This Report is presented in two volumes:

VOLUME I contains a discussion of the various standards and items of legislation, and a summary of the main parameters in tabular form.

VOLUME II is a reference volume containing complete copies of the actual standards referred to in Volume I.

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SUMMARY

Background

The quality and composition of petroleum products are usually determined and supervised by the petroleum industry itself in relation to the needs of the consumer. There is very little government regulation or supervision except for those substances (eg lead and sulphur) which cause atmospheric pollution.

The Energy Division commissioned AMDEL to assemble as much information as possible on legislation, standards and specifications for a range of petroleum products to provide a data bank on the petroleum industries activites and products.

Objectives

The aims of this Project were:

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- 1. To review existing standards for petroleum products.
- 2. To determine, where possible, to what extent Australian States and other countries have legislation controlling the standards of petroleum products.
- To assemble Australian industry specifications and/or typical analyses on a company by company basis for a specified range of petroleum products.

Summary of the Investigation

A review of the national standards which apply in the USA, UK and Australia has been carried out for petrol, LPG and various diesel and fuel oils. These standards specify only a number of essential properties of the product and do not attempt to give a complete specification. The amount of detail given varies from country to country and from one product to the next. One of the simplest standards is the Australian one for petrol. This defines relatively few properties and gives no composition details at all.

The US and UK standards are reasonably similar for most products. The Australian standards usually follow along the same lines but generally give fewer details. In the case of diesel and fuel oils there is no Australian standard at all. Production is nominally geared to comply with the relevant US or UK standard with some minor variations to suit Australian climatic conditions.

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Most of the legislation which could be found relating to specifications for petroleum products referred to those elements in the fuels which can cause atmospheric pollution. This referred mainly to lead, but some reference was also made to sulphur in fuel oils. In Europe, some countries also have legislation governing octane ratings. The EEC issues directives to its member countries on various aspects of fuel specifications. It has set a maximum content for lead in petrol, but some of the member countries impose even lower limits within their own boundaries. In Australia, lead levels are controlled by State legislation which varies from State to State.

All the oil refining companies in Australia were approached with a view to obtaining specifications for their products. Full specifications were obtained for all Ampol products and for Bass Strait LPG. Typical properties for the various products were supplied by Caltex, but other companies declined to give any information.

Conclusions

- 1. In general in the USA, Europe and Australia there are no legislative controls on the specifications for petroleum products other than those relating to the lead content of petrol. The only other legislation found was in Europe governing the octane rating of petrol and the sulphur level in automotive diesel oil and some fuel oils.
- 2. National standards for specified products are very similar in the USA and the UK. Australian standards are largely based on the other two. For diesel and fuel oils no Australian standard has been formulated. Instead, the industry follows the relevant overseas standards.
- Although the oil refining industry may be considered to be selfregulating in many respects, it is essentially regulated by
 the demands of its major customers. Large manufacturers and
 consumers ranging from the car industry to major users of fuel
 oils require constant product quality for satisfactory operation.
 Feed back from such groups probably regulates product quality
 more effectively than government legislation.

1. INTRODUCTION

The petroleum refining industry produces a large range of fuels which are essential to the current way of life in industrialised countries. The more important, high-volume products sold direct to individual consumers are petrol, diesel/distillate, liquefied retroleum gas, and a range of fuel oils.

Although these products are of such importance in the community, there appears to be very little government legislation to control the quality and composition of these fuels. The most noteable exception to this is the recent spate of legislation throughout the world to limit the lead content of petrol. Quality control is normally supervised by the industry itself.

In view of this and of the queries often received from some sections of the community, the Department of Mines and Energy commissioned AMDEL to review the existing standards for petroleum fuels production, the extent to which those standards are governed by legislation, and industry practice in relation to the standards.

The Report is presented in two volumes:

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- VOLUME I contains a discussion of the various standards and items of legislation, and a summary of the main parameters in tabular form.
- VOLUME II is a reference volume containing complete copies of the actual standards referred to in Volume I.

2. PRODUCT REVIEWS

2.1 Preamble

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When reviewing standards which apply in any industry today, it is interesting to consider the general procedure by which these standards have been developed. When a product such as a petroleum fuel is produced by several companies, it quickly becomes evident that it is almost impossible to design engines or burners to run efficiently on a fuel which varies significantly in quality and composition from one producer to the next. In some cases, there are important safety aspects which also have to be considered.

As a result, certain basic, essential qualities of the fuel are standardised by general agreement among producer companies. In some cases the Government has even requested that a certain standard be established. This procedure is usually organised by the Standards Association of the particular country by calling together senior technical representatives of all interested parties. The relevant standard then provides the basis for the production of a uniform product and the design of equipment which can be operated using the product from any of the producer companies. Thus, although the standard itself is not a legal document, it is clearly in the interest of each producer to conform to the requirements of the standard.

The Standards Association committee does of course take account of existing legislation when roumulating a standard, and is quick to respond to any legislative change, eg Part II of the Australian Standard for Petrol for Motor Vehicles (AS 1876) was published in 1984 to cover the new unleaded petrol which will soon be released onto the Australian market. In like manner, when the quality of a fuel is controlled by legislation, the regulations usually state that the quality will conform to the requirements as set out in the relevant standard, rather than specify another set of conditions. In this way there is considerable interaction between government and industry.

A standard may also obtain legal status when it is used as the basis for a supply contract, or when a company advertises that its products conform to a petroleum standard.

Because petroleum fuels are traded internationally it is convenient, and in some cases essential, to have similar standards in each country. As a result, Australian standards are often based on American (ASTM) and British standards, and in some cases, the overseas standard is used directly. Accordingly, standards from these three countries are reviewed in this report.

Even though there is an overall desire for standardisation, there are two complicating factors in the petroleum industry. Firstly each crude oil has its own peculiar blend of compounds which is reflected in the product mix that can be obtained from a refinery and in the quality of some of those products. Secondly, the volatility of petrol is altered to suit climatic conditions. As a result, rather different petrols may be on sale at any given time in various parts of a country if average prevailing temperatures differ significantly. These two factors do at times lead to a lack of uniformity in products on the market.

2.2 Petrol

2.2.1 National Standards

(1984)

The following standards apply to petrol in the USA, UK and Australia. The complete documents are included in Volume II of this report.

ASTM D 439 (1983) - Automotive gasoline

BSS 4040 (1978) - Petrol (gasoline) for motor vehicles
AS 1876 - Petrol (gasoline) for motor vehicles
(1982) - Part 1 - Leaded petrol

Part 2 - Unleaded petrol

ASTM D 439

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The ASTM standard recognises the need to produce a wide range of petrols and provides for five classes of volatility for each of these octane ratings. It then provides a table containing a comprehensive set of recommendations for the volatility class to be used in each State on a month-by-month basis.

The specifications for the five classes of petrol are listed in Table 1, while the anti-knock requirements (octane ratings) are listed in Table 3.

ASTM standards for other petroleum products refer to their use in formulating specifications for purchasing contracts and also make reference to government regulations. The petrol standard, however, makes no such references. This suggests that there are no government regulations because of the complexity of petrol composition and specifications.

The following statement is included in the standard:

"This specification is not a complete definition of gasoline. It describes various characteristics of gasoline used in a wide range of operating conditions. It does not necessarily include all types of gasolines satisfactory for automotive vehicles, nor necessarily exclude gasolines that may give unsatisfactory performance in certain operating conditions."

BS 4040

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The British Standard also defines its petrols by a range of distillation figures, but does not provide for different volatility classes. The composition of petrol is left wide open by stating simply that petrol shall consist essentially of volatile hydrocarbons together with additives as required. It shall not contain any water or any visible suspended matter.

Other criteria for sulphur and lead contents, copper corrosion, existent gum and oxidation stability are also stated, and these are almost identical to those in the American Standard. The specifications are listed in Table 2, and the anti-knock requirements are listed in Table 3.

AS 1876

The Australian Standard is similar to BS 4040, but is somewhat simpler in that it does not specify any distillation figures. The same general statement as used in BS 4040 is used with reference to the composition of petrol. The major changes in Part 2 dealing with unleaded petrol involve the lowering of the lead and sulphur contents, the virtual elimination of phosphorus compounds, and the introduction of NON as well as RON values to define anti-knock requirements. The specifications and anti-knock requirements are listed in Tables 2 and 3 respectively.

2.2.2 Legislation

USA

As explained in the previous section, there appears to be no legislation in the USA dealing with petrol properties. However, there are regulations governing the levels of lead and phosphorus in both leaded and unleaded petrol. These regulations appear to be promulgated by the Environmental Protection Agency (EPA) rather than enacted through parliamentary legislation. The limits for lead and phosphorus are given in Table 1, but the EPA intends to reduce the lead limit in leaded petrol from 1.1 g/l to 0.1 g/l in 1986.

The EPA also has the responsibility for approving any new additions to petrol, such as fuel extenders or octane boosters. The EPA has to be satisfied that the addition has no effect on automobile parts or performance, or on the environment. Accordingly, extensive test programmes are required.

TABLE 1 : REQUIREMENTS FOR PETROL

	(AST	M D439)			Sauce and the second
Volatility Class	A	В	С	D	Е
Distillation: *	 	. 7 1	Antonio de la constanta de la	en e	<u> </u>
Temperature °C for 10% max	70	65	60	55	50
Temperature °C for 50% min	77	77	77	77	77
Temperature °C for 50% max	121	118	116	113	1.1.0
Temperature °C for 90% max	190	190	185	185	185
End point, °C, max	225	225	225	225	225
Residue %, max	2	2	2	2	2
Vapour/Liquid ratio: *					
Test temperature °C	60	56	51	47	41
V/L, max	20	20	20	20	20
Reid vapour pressure, kPa, max	62	69	79	93	103
Lead content, max:					
- leaded, g/l	1.1	1.1	1.1	1.1	1.1
- unleaded, mg/1 [†]	13	1.3	13	13	1.3
Phosphorus, max, mg/1	1.3	1.3	13	1.3	1.3
Copper Strip corrosion, max	(· · · · · · · · · · · · · · · · · · ·	Class 1	n – 1885 is New Stransfersteller († 18	
Existent gum, mg/100 ml, max	5	5	5	5	5
Sulphur, %, max					
- leaded	0.15	0.15	0.15	0.15	0.15
- unleaded	0.10	0.10	0.10	0.10	0.10
Oxidation stability, min	240	240	240	240	240
그 전화일을 강된 문에 가는 그를 받았다면 그 것이라고 있는 그를 모르는 것을 먹었다.	in the second of the second	A DESCRIPTION OF PROPERTY	·维利·阿利克斯 10 克克克		

^{*} At 101.3 kPa

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 $^{^{\}dagger}$ The intentional addition of lead compounds is not permitted.

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TABLE 2: REQUIREMENTS FOR PETROL (BS 4040 and AS 1876)

		AS	1876
	BS 4040	Leaded	Unleaded
Distillation:			
Evaporated at 70°C, % (v/v)	min 10		
	max 45		
100°C, % (v/v)	min 36		
	max 70		
180°C, % (v/v)	min 90	un en	
Final boiling point °C	220		
Residue, % (v/v)	2		
Colour		(see below)	Yellow
Copper corrosion, 3 h at 50	°C Class 1	Class 1	Class 1
Sulphur content, % (m/m)	0.2	0.2 max	0.1 ma
Existent gum, mg/100 m1	5	4 max	4 max
Oxidation stability	240	240	240
Lead content at 15°C	0.05 g/1 m	iin* +	13 mg/l
	0.40 g/1	max	
Phosphorus content, mg/1			1.3

It has been found necessary to introduce a minimum limit for lead content to protect certain engines from valve seat recession.

Colour Coding of leaded petrol in Australia:

RON	Colour
89	Yellow
92	Purple
97	Red

[†] As permitted by government legislation

TABLE 3 : PETROL OCTANE RATINGS

and the second	Grade	RON	MON	(RON + MON)/2
1a	ASTM D 439 (leaded)			t talling a transport for the desired for the state of t
	*	•		92 min
	w	-	4	89 min
		• • • • • • • • • • • • • • • • • • •	•	87 min
1b	ASTM D 439 (unleaded)			
		en de la composition de la composition La composition de la	•	90 min
ing services Tables		<u>.</u>	.	87 min
				85 min
2	BS 4040	and the second of the second o		
	5 star	100 min	86 min	
	4 star	97 min	86 min	
	3 star	94 min	82 min	
	2 star	90 min	80 min	
3a	AS 1876 (leaded)			
	Premium	97 nominal		
		92 nominal		
	Standard	89 nominal		
3b	AS 1876 (unleaded)			
		[91 min	82 min	
		93 max		

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For example, in 1979 the EPA granted permission for the use of up to 7% methyl-tertiary-butyl-ether (MIBE) in gasoline as an octane booster. This followed tests on 12 vehicles over 120,000 miles during an 8-month period using petrols containing up to 15% MIBE.

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In Europe there is an interesting mixture of industry standards, legislation and EEC directives. In fact, it appears that some countries enact legislation to give legal status to EEC directives. The effect of EEC directives is illustrated by the following statements which appear in BS 4040.

"The fuels covered by this standard are suitable for use in engines designed to comply with Regulations ECE 15 Amendments 01 and 02 of the Economic Commission for Europe (ECE) of the United Nations, and with Directives 70/220/EEC, 74/290/EEC and 77/102/EEC of the European Economic Community (EEC), as covered by the Road UK Traffic Act 1972 Sec.40(1) and (3) and the Motor Vehicle (Construction and Use) Regulations 1973, as amended."

"In view of the agreement reached within the European Economic Community in Directive 78/611/EEC to restrict the maximum lead content of all petrol sold within the community to 0.40 g/l from 1 January 1981, provision has been made to reduce the corresponding limit in this standard from that date."

Table 4 presents a summary of octane ratings and maximum lead contents in petrols sold in Europe and shows which countries rely on industry standards and which have legal requirements. All member countries of the EEC adhere to the 0.40 g/l maximum for lead, but it is interesting to note that some countries have imposed a more stringent limit of 0.15 g/l. The lead limits imposed by some other countries are listed in Table 5.

Australia

There is no Commonwealth legislation in Australia dealing with petrol quality. This responsibility has apparently been delegated to the individual States.

TABLE 4: LEAD LIMITS AND OCTANE RATINGS OF EUROPEAN PETROL *

************		emium gra	ıde	Reg	gular gr	ade	Planned - changes
	RON (min)	MON (min)	Lead content (g/1 max)	RON (min)	MON (min)	Lead conten (g/1 ma	t after Jan.1,
gradus — a stantigada a probabilitati da indicato de probabilitati	Titang Tabuki salah kecama				<u> </u>		andron gant and an element the principal contribution of the desired contribution of features ("distributions
Austria	98.0	†87.0	0.15	88.0	†79.0	0.15	
Belgium/ Luxemborg	98.0	+88.0	0.40	91.0	181.0	0.40	Lead levels in Belgium to be reduced to 0.15 g/l by Jan 1,1987
Denmark †	98.0	87.0	0.40	92.0	81.0	0.15	Premium lend level to be reduced to 0.15
France	97.0	†87.0	0.40	90.0	80.0	0.40	g/1 in July 1984
West Germany	97.4	87.2	0.15	91.0	82.0	0.15	Govt.discussions with respect to introduction of unleaded gasoline by Jan. 1, 1986
Greece	96.0		0.40	90.0		0.4	Lead reduced to 0.15 g/l in Atticarea effective June 1, 1983
Ireland §	97.4	86.5	0.40	90.0	82.0	0.40	
Italy	97.0	87.0	0.40	84.0	+80.0	0.40	
Netherlands	98.0	+88.0	0.40	91.0	+81.0	0.40	Lead Level to be reduced to 0.15 g/l by October 1986
Norway f	98.0	87.0	0.15	93.0	85.0	0.15	
Spain	96.0	84.0	0.60	90.0		0.48	Probable reduction to 0.4 g/l following BEC entry in 1985-86. Possibling increase in premitted to 2.5 possibling to 2.5
Sweden+	98.0	87.0	0.15	92.0	85.0	0.15	ium to 97 RON un der discussion.
Switzerland	98.0	88.0	0.15	90.0	81.0	0.15	
UK	97.0	+87.0	0.40	90.0	+81.0	0.40	Lead level to be reduced to 0.15 g/l by Jan. 1, 1986.

^{*} Specification as of Jan. 1 1984. Where specifications are minimum legal requirements, industry specifications are typically 0.6 RON (0.8 NON) higher to allow for test reproducibility typical industry specifications only Industry specification

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TABLE 5 : LEAD LIMITS IN SOME OTHER COUNTRIES

		Rational Property and the second				
3	Country	gPb/ litre	Effective Date	Status	Regulating Body	Regulating Instrument
	New Zealand	0.84	1967	Advisory	Petroleum Industry	Commercial Practice
		0.45	1985/86 (Estimated)	Advisory	Dept. of Heal th	Recommen- dation of Clean Air Council
	Japan	0.31	July 1971	Advisory	Council for Transport Technics and Industrial Structure Council (Advisors to Japanese	Industrial Standardis- ation Law Japanese Industrial Standard (JIS), amended
		0.02	Feb. 1975	Advisory	Covernment)	July 1970
	Republic of South Africa	0.836	Current	Advisory	Representative Supplier Consumer Technical Committee with S.African Bureau of Standards	current revision)
	Canada	0.77	Jan. 1976	Legal	Department of Environment	Sec.22, Clean Air Act, Canada Gazetto Pt II, Vol 108 No. 15, 14/8/7

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No restrictions, other than commercial limits apply in Eastern Europe (incl. E. Germany), South America, the Middle East, Africa and Asia.

SOURCE: Australian Institute of Petroleum

As a result, even the limits for lead content vary from State to State. The maximum effectiveness of lead alkyl addition is obtained at an equivalent lead concentration of 0.84 g/l. The figure was adopted as industry practice Australia wide in 1967, and some States still use this figure. However, other States have legislated to reduce the lead content to varying degrees as detailed in Table 6. Unleaded petrol was introduced throughout Australia in July 1985, but leaded premium grade petrol will be available until close to the end of this century.

Enquiries have been made in all States regarding the existence of any legislation dealing with petrol quality. There appears to be no legislation other than that dealing with lead levels.

2.2.3 Industry Practice

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In Australia there is no standard specification for petrol, but each company has its own set of specifications. These are usually expressed in terms of maximum or minimum values for each property. The typical composition of the petrol is normally well within the specified limits, and hence both the specification and the typical properties are needed to define the product fully.

The oil companies operate an exchange system for petrol to save interstate transport costs. For example, Mobil sells to all other companies in South Australia and buys in return a similar amount in Brisbane, Sydney and Perth where it has no refinery. This ensures that there is a large degree of similarity in the products of all companies but it does not prevent each company adding its own special additives to the petrol.

The volatility of the petrol is varied throughout the year by producing three different blends, viz, summer, winter and intermediate. However, the variations in volatility are not nearly as important here as they are in Europe and North America where the winters are much more severe.

Changes in the RON value of petrol are governed by a balance of the demands of the motor car industry and the cost of production, not by Government regulation. In August 1968, the RON for premium grade petrol rose from 97 to 98. This consumed a large amount of extra crude oil to raise the octane rating in this manner, but this was acceptable in 1968. In August 1979, after rapid increases in oil prices for a number of years, the RON was reduced back to 97 to reduce the quantity of oil used.

The oil companies throughout Australia were contacted and asked for their specifications for petrol and a number of other products. Replies were received as follows:

TABLE 6 : LEAD LIMITS IN AUSTRALIAN STATES*

State	Date	Lead, g/l
Queens1and NSW		0.84
(Sydney, Wollongong/Newcastl	e only) 1/1/75	0.64
	1/1/77	0.45
	1/1/80	0.40
NSW-Other	400 julio 1980 julio 1 National 1980 julio 1	0.84
Victoria	1/10/75	0.60
	1/1/77	0.50
요한 일하다 그릇을 다른 하는 사람이	1/1/79	0.45
	1/1/83	0.30
South Australia	1/1/84	C.65
Western Australia		0.84
Tasmania	1/2/76	0.64
	1/1/77	0.50
	1/1/79	0.45

Source: Australian Institute of Petroleum

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^{*} Unleaded petrol, as specified in AS 1876, Part 2 (1984), was introduced throughout Australia on 1 July 1985. However, leaded premium grade petrol will remain available until approximately the turn of the century.

- Ampol Refineries Limited sent full product specifications for every product produced in their Brisbane refinery.

 These are reproduced in full in Appendix A.
- Caltex Oil (Australia) Pty Limited replied on behalf of Australian Oil Refining Co Limited and provided typical properties only for petrol, automotive diesel oil and fuel oil. These are listed in Appendix B.
- Mobil Oil Australia Limited declined to provide any information from its head office, but distillation figures for petrol were supplied from the Adelaide office and these are listed in Appendix C.
- BP Refinery Pty Limited and Shell Refining (Aust) Pty Limited also declined to provide any information.
- The Oil and Gas Division of the BHP Co Limited was contacted in relation to LPG only. A full specification was provided and is reproduced in Appendix D.

There is insufficient information in Appendices A, B and C to enable a comparison to be made of the petrol quality from different companies as there is a mixture of specifications and typical properties.

2.3 Liquefier Petroleum Gas

2.3.1 National Standards

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The following standards apply to LPG in the USA, UK and Australia. The complete documents are included in Volume II of this report.

ASTM D1835 (1982) - Liquified Petroleum Gases BSS 4250 (1975) - Commercial Butane and Propane

In Australia, there is no Australian Standard covering these substances. However, an equivalent document entitled "Liquefied Petroleum Gas Specifications and Test Methods" was produced by the Australian Liquefied Petroleum Gas Association (ALPGA) in 1962, with the latest revision being in 1973. Now that LPG is being used more commonly in motor vehicles, the ALPGA and the Australian Institute of Petroleum Limited have issued an Interim Specification for Automotive LPG in February 1985.

AS'IM D1835

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The ASTM standard recognises that LPG can have a very wide range of compositions depending on whether it is obtained from the processing of natural gas and its assocaited gases and liquids, or as a by-product from a conventional oil refinery. Standard specifications are given for commercial propane, commercial butane, mixtures and special duty propane. The last one differs from commercial propane only in its propylene and sulphur contents. The detailed requirements are listed in Table 7.

TABLE 7: REQUIREMENTS FOR LPG (ASTM 1835)

	Commercial Propane	Commercial Butane	Commercial PB Mixtures	Special-Duty Propanc
Vapor pressure at 100°F (37.8°C), max, psig	208	70		208
kPa	1430	485		1430
Volatile residue:				
evaporated temperature 95%, max. °F	, +37	36	36	-37
•C	-38.3	2.2	2.2	-38.3
or				
butane and heavier, max, vol %	2.5			2.5
pentane and heavier, max, vol %		2.0	2.0	
Propylene content, max, vol %				5.0
Residual mätter:				
residue on evaporation 100 ml, max. ml	0.05	0.05	0.05	0.05
oil stain observation	pass	pass	pass	pass
Relative density (sp.gr. at 60/60°F (15.6/15.6°C) report	report	report	report
Corrosion, copper, strip	, No. 1	No. 1	No. 1	No. 1
Sulfur, grains/100 ft ³ ma at 60°F and 14.92	ix 15	15	15	10
psia mg/m³(15.6°C and 101. kPa)	343	343	343	229
Hydrogen sulfide content				pass
Moisture content	pass			pass
Free water content		none	none	

BS 4250

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A summary of the main specifications related to quality in the British Standard are listed below:

1. General Requirements

Total Sulphur 0.02% (m/m) max. Hydrogen sulphur 0.5 ppm (v/v) max. Acetylenes 2 moles per cent max.

2. Requirements for Commercial Butane

Description: Commercial butane shall be a hydrocarbon mixture consisting predominantly of butanes and/or butylenes. It shall not contain harmful quantities of toxic or nauseating substances and shall be free from mechanically-entrained water.

Mercaptan sulphur 0.004% (m/m) max.

Volatility 95% (v/v) evaporation at 2.2°C

Vapour pressure 5.86 bar max. at 45°C

Dienes 10 moles per cent max.

3. Requirements for Commercial Propane

Description: Commercial propane shall be a hydrocarbon mixture consisting predominantly of propane and/or propylene. It shall not contain harmful quantities of toxic or nauseating substances and shall be free from mechanically-entrained water.

Mercaptan sulphur 0.005% (m/m) max.

C2 hydrocarbons 5.0 moles per cent max.

Ethylene 1.0 moles per cent max.

C4 and higher hydrocarbons

C5 and higher hydro2 moles per cent max.

carbons
Vapour pressure 17.6 bar max at 45°C

It can be seen from the above that the compositions of propane and butane can vary considerably. The major control is actually the vapour pressure which in effect limits the amount of light hydrocarbons present.

ALPGA Specifications

In these specifications, LPG (both commercial and automotive) is defined as a material which is comprised predominantly of any of the following hydrocarbons or mixtures of all or any of them - propane, propylene, butanes or butylenes. The descriptions of commercial propane and butane individually are the same as given in BS 4250.

In contrast to the British Standard, the ALPGA Specifications for commercial LPG make little reference to composition with respect to other hydrocarbons, but concentrate more on such properties as heating value and vapour pressure. As a result, there is considerable latitude allowed in the actual composition of the product.

In the automotive LPG specifications, an upper limit of 0.5% has been placed on the content of butadienes which are believed to be the major source of deposits in vehicle fuel systems. There are no other limits on composition, but the allowable vapour pressure range in effect limits the proportion of butane that can be present.

The specifications for commercial and automotive LPG are listed in Tables 7 and 8 respectively.

2.3.2 Legislation

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In South Australia, the Regulations under the Dangerous Substances Act state that the quality of liquefied petroleum gas shall conform to the requirements of the ALPGA Specifications. The Regulations do not attempt to qualify or override the ALPGA Specifications in any way.

No references were found to similar quality control legislation overseas, although indices of overseas legislation are not readily available. There do appear to be many regulations which govern the storage of LPG and the quality of the cylinders in which it is sold, but these regulations are not the concern of this report.

2.3.3 Industry Practice

According to advice received from the South Australian Gas Company (SAGASCO) South Australia obtains its supplies of LPG almost entirely from Port Bonython, except for the southern-regions (Nount Gambier, Naracoorte, etc.) which obtain their supplies from Victoria.

The Port Bonython LPG contains no unsaturated hydrocarbons. The typical composition is as follows: > 98% propane, 0.5% butane and 0.4% ethane.

Prior to the opening of the installation of Port Bonython, most of the LPG came from the PRA Refinery at Port Stanvac and contained 90 - 95% propane with the remainder being butane, ethane and pentane. Supplies from Port Stanvac to SACASCO have been virtually discontinued.

The Victorian LPG supplied to the South-East comes entirely from Bass Strait and its composition is similar to that from Port Bonython. Until a few years ago, the Victorian LPG contained a proportion of material from the Shell refinery at Corio. This contained a considerable percentage of propylene, and the blended material contained about 4% propylene. This fuel produced soot when burnt and hence was an inferior fuel for motor vehicles. With the increasing use of LPG in motor vehicles, this supply from the refinery has been discontinued.

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Specifications for LPG produced by the Ampol refinery in Brisbane and by BHP from Bass Strait were provided by those companies and are reproduced in Appendices A and D respectively.

TABLE 8 : AUSTRALIAN SPECIFICATIONS FOR COMMERCIAL LPG

Property	Propane	Butane	Mixtures
Volatile sulphur, g/m³	0.34 max	0.34 max	0.34 max
Heating value, MJ/kg Vapour pressure	48.8 min	47.7 min	47.7 mi.n
at 40°C, kPa Volatile residue	1530 max	520 max	1.530 max
a, °C *	-38 max	2 max	2 max
b, % (v/v)	2.5 max	2 max	2 max

^{*} a. The temperature at which 95% by volume of the product evaporates.

b. The content of heavier hydrocarbons by liquid volume

TABLE 9: AUSTRALIAN INTERIM SPEICIFICATION FOR AUTOMOTIVE LPG

Property	Specification Value
Corrosion, Copper Strip	No. 1 max.
Dienes, % vol.	0.5 max.
Dryness:	
(a) if vapour pressure exceeds 1240 kPa gauge at 40°C	Pass
(b) other mixtures	No entrained water
Motor Octane Number (calculated)	92 min.
Odour	Distinctive, unpleasant but non- persistent down to concentrations in air of 1/5 lower limit of flamability.
Olefins, % vol.	Report
Residue on Evaporation, mg/100 mL	2.0 max.
Vapour Pressure @ 40°C, kPa gauge	800-1530
Volatile Residue:	
95% evaporated temp. @ 760 mm Hg, °C	2 max.
Volatile Sulphar:	
@ 15°C, dry and 101.325 kPa, mg/m ³	340 max.
교통하다면 그리 문문하다는 얼마를 보고 안.	보다를 할 수 있다. 그렇게 중 호텔들은 그래?

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2.4 Automotive Distillate and Fuel Oils

2.4.1 National Standards

The following standards apply to these products in the USA and UK. The complete documents are included in Volume II of this report.

ASTM D396 (1980) - Fuel oils

ASTM D975 (1981) - Diesel fuel oils

BS 2869 (1983) - Fuel oils for oil engines and burners for non-marine use.

There are no Australian Standards relating to the quality of these products. Australian production essentially follows the specifications as detailed in the above standards.

ASTM D396

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Seven different grades of fuel oil are specified in this standard. A description of each of these oils is listed below:

- No. 1 A distillate oil intended for vaporising pot-type burners and other burners requiring this grade of fuel.
- No. 2 A distillate oil for general purpose heating for use in burners not requiring No. 1 fuel oil.
- No. 4 An oil for burner installations not equipped with (light) preheating facilities.
- No. 4 As for No. 4 light.
- No. 5 A residual type oil. Preheating may be required (light) depending on climate and equipment.
- No. 5 Preheating may be required for burning and, in cold (heavy) climates, may be required for handling.
- No. 6 Preheating is required for burning and handling.

The properties specified for these products are listed in Table 9.

ASTM D975

Three grades of diesel fuel are specified as follows:

TABLE 10: ASTM SPECIFICATIONS FOR FUEL OILS (ASTM D 396)

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		No. 1	No. 2 No	No.4 (light)	No. 4	No.5 (light)	No.5(heavy)	No. 6
Flash point, "C min		38	38	38	55	55	1	
Four point, °C max		-18	φ	9-	١٧		Ċ	ò
Water and sediment, % (v/v) max	max	0.05	0.05	0.50	0.50	-	, C	1 (
Carbon residue on 10% bottoms, & max	ms, e max	5	0.35	1		.	1	7.7
Ash, wt & max				0.05	-	0.10	(†	f .
Distillation temperatures, °C	Ų				÷	OT.	0.10	r ·
10% point max		215		1				
90% point min		•	282	1		1		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
		288	338				t	
Saybolt viscosity, sec *							r	
Universal at 38°C	1		32.6	32.6	45	>125	>300	>900
	шах		37.9	45	125	300	006	0006
furol at 50°C				4	1	. 1	23	>45
	max		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			•) V	2002
Kinematic viscosity, cSt							ò	200
At 38°C	mâm	1,4	2.0	2.0	ιν 8	>26.4	765	
	max	2.2	3.6	بر ف	26.4		107	K K
At 40°C	min	ri N	1.9	*	5.5	>24.0	134 >58	• • • • • • • • • • • • • • • • • • •
	тах	2.1	5.4		24.0	28	168	
At 50°C	nin.					i. 1	42	- 00
	max			1.		0		200
Specific Gravity, deg API	Xem M	0.8499	0.8762	0.8762	1		TO 1	000
Copper strip corrosion,	max	No. 3	No. 3		- 1			r
Sulphur, %	max	5.0	0.5					
							•))

* Saybolt viscosities are for information only. They are not specification limits.

Invited	
	No. 1 - D - A volatile distillate fuel oil for engines requiring frequent speed and load changes.
	No. 2 - D - A distillate fuel oil of lower volatility for engines in industrial and heavy mobile service.
#*****	No. 4 - D - A fuel oil for low and medium speed engines.
	The properties of these oils are listed in Table 10.
a	BS 2869
	The British Standard specific two grades of engine oil and seven classes of burner oil as follows:
	Engine Fuels:
	Class A1 - a distillate oil of high quality for use as automotive diesel fuel.
: -	Class A2 - a general purpose diesel fuel.
	The properties of these oils are listed in Table 11.
]	Burner Fuels:
	Class C1 - distillate fuels of the kerosine type C2 C1 for domestic heating C2 for vaporising and atomising burners
1	Class D - distillate grade for atomising burners in domestic and industrial use. It can be stored and used at normal ambient temperatures.
	Classes E - residual fuels which may require preheating for to H combustion and handling.
	Properties of these products are listed in Table 12.

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TABLE 11: ASTM SPECIFICATIONS FOR DIESEL FUEL OILS (ASTM D975)

	1-D	2-D	4 -D
Flash point, °C min	38	52	55
Water and sediment, % (v/v) max	0.05	0.05	0.50
Carbon residue on 10% residium, % max	0.15	0.35	
Ash, wt %, max	0.01	0.01	0.10
Distillation temperatures, °C			
90% point min		282	
max	288	338	
Viscosity:			
Kinematic, cSt at 40°C			
min	1.3	1.9	5.5
max	2.4	4.1	24.0
Saybolt, sec. at 38°C			
min		32.6	45.0
max	34.4	40.1	125.0
Sulphur, % max	0.50	0.50	2.0
Copper strip corrosion, max	No.3	No.3	
Cetane No. , min	40	40	30

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TABLE 12: BS SPECIFICATION FOR ENGINE FUELS (BS 2869)

Class	Λ1	A2
Viscosity, kinematic at 40°C, cSt		
min	1.50	1.50
max	5.00	5.50
Cetane number, min	50	45
Carbon residue, Ramsbottom on 10% residue,		
% (m/m), max.	0.20	0.20
Distillation, recovery at 350°C, % (v/v), min	85.0	85.0
Flash Point, closed, Pensky-Martens, °C, min	56.0	56.0
Water Content, % (v/v), max	0.05	0.05
Sediment, % (m/m), max	0.01	0.01
Ash, % (m/m), max	0.01	0.01
Sulphur content, % (m/m), max	0.30	0.50
Copper corrosion test, max	1	1
Cold filter plugging point °C, max	1919 - 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0
Summer (March/September inclusive)		
Winter (October/February inclusive)	. 9	9

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TABLE 13: BS	SPECIFICATIONS	FOR	BURNER	HIELS	CRS	2860	١
		- 011	DOIGHAIL	بريرين د	(1)0	4000	1

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Class	C1	C2	D	Е	Ŀ	G	H
Viscosity, kinematic, cSt		 					
at 40°C		100					
min		1.00	1.50	, .			
max		2.00	5.50	<u></u>		-	
at 80°C, max	-		2	13.50	35.00	85.0	130.0
Carbon residue, Ramsbottom on 10% residue, % (m/m)			n 5				
Distillation		**	0.2	• • • · · · · · · · · · · · · · · · · ·	-	•	-
recovery at 200°C % (v/v) min	15.0	15.0					
recovery at 200°C % (v/v) max	60.00						
recovery at 350°C % (v/v) min			85.0				
final boiling point, °C max	280	300	= ,,				
Flash point, closed, Abel °C, min	43.0	38.0	in en er Juliu ¥ilili				
Flash point, closed, Pensky- Murtens, °C, min		_	56.0	66.0	66.0	66.0	66.0
ater content, % (v/v), max			0.05	0.5	0.75	1.0	1.0
Sediment, % (m/m) max			0.01	0.15	0.25	0.25	0.25
Ash, % (m/ni) max	•		0.01	0.15	0.15	0.20	0.20
Sulphur content, % (m/m), max	0.04	0.20	0.50	3.50	3.50	4.00	4.00
Copper corrosion test, max	No.1	No.1	No.1	***	44.		_
Cold filter plugging point °C N	hx.						
Summer (March/Sept. incl)			Ö				
Winter (Oct./Feb. incl)			4 9				
Smoke point, mm, min	35	20					
Char value, mg/kg, max	10	20				si Tindid A # igada	

2.4.2 Logislation

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No reference has been found either in Australia or overseas to legislation which regulates the overall composition and quality of distillate and fuel oils, although individual items such as sulphur content are regulated in some cases.

The ASTM Standards include the following statement:

"Nothing in this specification shall preclude observation of federal, state or local regulations which may be more restrictive."

The regulations referred to would normally relate either to sulphur content or to safety aspects of storage and handling. Some local areas may require a higher flash point for some products for safety reasons and this will alter the overall product specification.

In the UK, the sulphur limit is regulated for Class A1, A2 and D fuels. The limits were set in accordance with the legislative requirements of the Council Directive 75/716/EEC of the European Economic Community on the approximation of the laws of Member States relating to the sulphur content of certain liquid fuels as embodied in Statutory Instrument 1976 No. 1988 Public Health - The Motor Fuel (Sulphur Content of Gas Oil) and Statutory Instrument 1976 No. 1989 Public Health - The Oil Fuel (Sulphur Content of Gas Oil).

This general approach to legislation is similar to that for petrol where the major legislative controls apply to those elements which cause atmospheric pollution. The overall composition and quality control is usually left in the hands of industry.

2.4.3 Industry Practice

In Australia, distillate and fuel oils are manufactured to meet, in general, the requirements of the ASTM and British Standards. However, the products are made for Australian conditions and do not necessarily meet the ASTM and British Standard Specifications exactly. The following products are manufactured:

- 1. Lighting Kerosene a highly refined straight distillation product having excellent burning characteristics. It is mostly used in domestic heaters, lamps and refrigera are. It can be used in some industrial heaters.
- 2. Heating Oil a straight distillation product which is clean burning, transparent, free-flowing and liquid at very low temperatures. It is used mainly in domestic space-heating appliances and in small industrial equipment.

3. Automotive Distillate - a product similar to heating oil but with a slightly higher viscosity. It is used in fully automatic domestic central heating systems and in high-speed diesel engines.

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- 4. Industrial Diesel Fuel a heavier grade of fuel which is free-flowing and does not require pre-heating. It is used in commercial heating installations, many industrial and metallurgical furnaces, small boiler plants, and slow and medium speed diesel engines.
- 5. Furnace Fuel mainly a heavy residual from distillation of crude oil. It is manufactured in two grades high and low sulphur -- depending on environmental or customer requirements. It is used mostly in steam generating plants, large industrial furnaces and brick kilns.

The general properties of these fuels and the overseas standards to which they approximate are listed in Table 13. Typical physical properties of a wide range of petroleum products manufactured in Australia are listed in Table 14.

As indicated in a previous section, the oil companies throughout Australia were approached for information on their specifications. Full specifications of a range of products produced by Ampol are reproduced in Appendix A, while typical properties for Caltex fuel oil and automotive diesel oil are listed in Appendix B.

TABLE 14: PROPERTIES OF AUSTRALIAN FUEL OILS

	Lighting Kerosine	Heating Oil	Automotive Distillate	Diesel Fuel	Furn High S	ace Fuel . Low S
Flash point, °C	4.8	61 min	61 min	61 min	61 min	61 min
Density, kg/l	0.79	0.82	0.84	0.855	0.98	0.90
Sulphur, wt %	0.03	0.1	0.4	0.5	3.0	1.0
Energy, MJ/kg	46.4	46.0	45.7	45.5	42.9	44.5
MJ/1	36.7	37.7	38.4	38.9	42.0	40.1
Equivalent Specification						
AS'IM D 396		No. 1	No. 2	No. 4	No.	5
ASTM D 975		.	No. 2-D	No. 4-D		
BS 2869			A1 & D	B1 & D	F	

Source : Australian Institute of Petroleum

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: TYPICAL PHYSICAL PROPERTIES OF AUSTRALIAN PETROLEUM PRODUCTS TABLE 15

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Bulk Nbdu- lus (Compressib.	900 1200	1450 1450 1600 1600 1700	1750 2050 1900 2250 1600	1400	1850 1900 1900 1950	2070	
Coefficient of Cubical Expansion	0.00390 0.00200 0.00120 0.00110	0.00094 0.00094 0.00087 0.00087 0.00084	0.00082 0.00070 0.00075 0.00063	0.00120 0.00110 0.00100 0.00095	0.00077 0.00076 0.00076 0.00074 0.00074	0.00031	
Auto- Ignit- ion Temo°C	500 480 440 390	380 380 380 350 350	360 380 380 480 350	600 580 520 250 250	410 (410 (410 (410 (410 (ı	
Flash Point °C Class		40B 48B 35B 65C 89C	80C 90C 210D -15A	-11A 5A 28B 32B 32B	2000 2100 2100 2200 2200 2200		
Vapour Pressure kPa @40°C	1300 550 38 to 50 65 to 85	Ω	11 11 12 <u>0</u> <u>7</u>	22 7.6 Below 3.5			
Pour Point °C	BelowO ""	 -4 to 15	0 to 3 6 to 24 45 - 15	5 Below 0 " I	-20 -20 -15 -10 -10	0	
Viscosity mm²/s (centistokes) 15° 40°C 100°C	0.08		2.0 15 4 2000 1.9	1.0	9 8 0 5 8		
Viscosity nm2/s entistoke 5° 40°C	0.00 0.15	11.5 2.5 4.0 4.0	5.0 130 Gel Solid 3.0	सम्म०म रांदांद्धांद	50 50 80 150 200		
at	0.15	2.0 2.0 3.0 7.0	10.0 750 Gel Solid Gel	2.0 2.0 1.0 2.0	120 250 400 750 1500	1.0	
Density Correction Factor/°C	0.00140 0.00110 0.00085 0.00079 0.00081	0.00072 0.00072 0.00068 0.00068	0.00066 0.00062 0.00063 0.00061 0.00068	0.00097 0.00088 0.00079 0.00073	0.00065 0.00064 0.00064 0.00063 0.00063	0.00031	
Litres per Tonne	1960 1720 1440 1350 1380	1260 1270 1230 1220 1190	1170 1020 1110 980 1260	1140 1150 1160 1280 1220	1140 1120 1120 1110 1110	1000	
Density at 15°C	0.510 0.580 0.695 0.740	0.795 0.790 0.810 0.820 0.840	0.855 0.980 0.900 1.020 0.796	0.880 0.870 0.860 0.780 0.820	0.880 0.890 0.900 0.900	1.00	
PRODUCT	LPG - Propane - Butane Aviation Gasoline Petrol - Super 97 RON - Standard 89 RON	Aviation Turbine Fuel Lighting Kerosine Power Kerosine Heating Oil Automatic Distillate	Industrial Diesel Fuel Fuel Oil : High Sulphur Low Sulphur Bitumen Crude Oil (Bass Strait)	Benzene Toluene Xylene White Spirit Mineral Turpentine	Lube 10W Oils 20 SAE 30 40 50	Water	

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3. CONCLUSIONS

- 1. In general, in the USA, Europe and Australia there are no legislative controls on the specifications for petroleum products other than those relating to the lead content of petrol. The only other legislation found was in Europe governing the octane rating of petrol and the sulphur level in automatic diesel oil and some fuel oils.
- 2. National standards for specified products are very similar in the USA and the UK. Australian standards are largely based on the other two. For diesel and fuel oils no Australian standard has been formulated. Instead, the industry follows the relevant overseas standards.
- 3. Although the oil refining industry may be considered to be selfregulating in many respects, it is essentially regulated by the
 demands of its major customers. Large manufacturers and consumers
 ranging from the car industry to major users of fuel oils require
 constant product quality for satisfactory operation. Feed back
 from such groups probably regulates product quality more effectively
 than government legislation.

APPENDIX A

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AMPOL PRODUCT SPECIFICATIONS

PREMIUM GASOLINE

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Method	Test		Specifica	ition
Visual	Colour (1)	Red		
ASTM D130	Corrosion, Copper Strip, 3 hrs at 50°C	1 Max		
ASTM D1298	Density at 15°C	Report		
ASTM D86	Distillation	Summer(2)	Intermed.	(3)Winter (4)
	10% Evaporated, Max°C	60	60	57
	30% Evaporated, Min°C (5)	69	66	63
	50% Evaporated, Max°C	115	110	110
	90% Evaporated, Max°C	180	180	180
	Final Boiling Point, Max°C	228	228	228
	Residue, Volume % Max	2	2	2
IP 30	Doctor Test (6)	Negative		
AS'IM D381	Gum, Existent, mg/l	40 Max		
ASTM D626 (7)	Lead Content, gPb/1	0.836 Max		
ASTM D2699	Octane Number, Research	97.0 Min	(8)	
ASTM D525	Oxidation, Stability Minutes	240 Min		
ASTM D323	Reid Vapour Pressure, kPa (5) Max	65.5	72.5	80.0
ASTM D2533	36:1 V/L, Temperature, °C (5) (9)	Report		

Effective Date: 1 October 1984

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- Red is defined as: at least equivalent on visual inspection to a
 mg/l solution of Mortons Automate Red B in iso octane.
- (2) Summer: for delivery to the respective regions between these dates:
 Brisbane : October 16 to February 29

 North of Brisbane : September 16 to March 31
- (3) Intermediate: for delivery to the respective regions between these dated:-

Brisbane : March 1 to April 15

: September 1 to October 15

North of Brisbane : April 1 to September 15

(4) Winter: for delivery to Brisbane only between these dates:April 16 to August 31

- (5) Alternatively these specification points may be waived providing that the Critical 36:1 V/L Ratio minimum limits are met for the delivery period. However, 30% Evaporated and RVP results are to be recorded. The Critical Monthly Values for 36:1 V/L ratio are attached.
- 76) Alternatively, a maximum value of 15 $\mu g/g$ S Mercaptan Sulphur by ASTM D3227 shall apply.
- (7) Alternatively, an X-ray fluorescent test method may be used.
- (8) A volume weighted monthly average of 97.0 minimum shall apply. No individual batch shall be less than 96.8.
- (9) Alternatively the equation

T, °C 36:1 V/L = $49.3 + 0.454t_{30} - 0.31$ RVP may be used.

CRITICAL 36:1 V/L LIMITS °C MINIMUM

		Brisbane	Northern Region
The same and a same		FO F	
January		58.5	59.0
February		58.5	59.0
March		56.5	59.0
April	1.2	56.0	57.0
May		52.0	55.0
June		51.0	55.0
July		51.0	55.0
August		51.0	55.0
September		55.5	57.5
October		55.5	59.0
November		58.0	59.0
December		58.0	59.0

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REGULAR CASOLINE

Metho	Test		Specific	ation
Visual	Colour (1)	Yellow		
ASTM D130	Corrosion, Copper Strip, 3 hrs at 50°C	1 Max		
ASTM D1298	Density at 15°C	Report		
ASTM D86	Distillation	Summer(2)	Intermed.	(3)Winter(
	10% Evaporated, Max°C	60	60	57
	30% Evaporated, Min°C (5)	69	66	63
	50% Evaporated, Max°C	115	110	110
	90% Evaporated, Max°C	180	180	180
	Final Boiling Point, Max°C	228	228	228
	Residue, Volume % Max	2	2	2
IP 30	Doctor Test (6)	Negative	garan saka Kabupatèn	
ASTM D381	Gum, Existent, mg/	40 Max		
ASTM D626 () Lead Content, gPb/1	0.836 Max		
ASTM D2699	Octane Number, Research	89.0 Min	(8)	
AS'IM D525	Oxidation, Stability Minutes	240 Min		
ASTM D323	. Reid Vapour Pressure, kPa (5) Max	65.5	72.5	80.0
ASTM D2533	36:1 V/L, Temperature, °C (5) (9)	Report		

Effective Date: 1 October 1984

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- (1) Yellow is defined as: at least equivalent on visual inspection to 1.8 mg/l of Williams' Yellow DEA or Waxoline Yellow EDS in iso octane.
- (2) Summer: for delivery to the respective regions between these dates:-

Brisbane

: October 16 to February 29

North of Brisbanc

: September 16 to March 31

(3) Intermediate: for delivery to the respective regions between these dated:-

Brisbane

: March 1 to April 15

: September 1 to October 15

North of Brisbane

: April 1 to September 15

(4) Winter: for delivery to Brisbane only between these dates:

April 16 to August 31

- (5) Alternatively these specification points may be waived providing that the Critical 36:1 V/L Ratio minimum limits are met for the delivery period. However, 30% Evaporated and RVP results are to be recorded. The Critical Monthly Values for 36:1 V/L ratio are attached.
- (6) Alternatively, a maximum value of 15 μ g/g S Mercaptan Sulphur by ASTM D3227 shall apply.
- (7) Alternatively, an X-ray fluorescent test method may be used.
- (8) A volume weighted monthly average of 89.0 minimum shall apply. No individual batch shall be less than 88.8.
- (9) Alternatively the equation

T, °C 36:1 V/L = $49.3 + 0.454t_{30} - 0.31$ RVP may be used.

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CRITICAL 36:1 V/L LIMITS °C MINIMUM

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	Brisbane	Northern Region
January	58.5	59.0
February	58.5	59.0
March	56.5	59.0
April	56.0	57.0
May	52.0	\$5.0
June	51.0	Š 5.0
July	51.0	55.0
August	51.0	55.0
September	55.5	11 (5.7.5 (j.) 15 (j.)
October	55.5	59.0
November	58.0	59.0
December	58.0	59.0

PRODUCT SPECIFICATION PROPANE L.P.G.

	Method	Test	Specification
	Calculated from Composition A.L.P.G.A.	Calorific Value, Gross, MJ/kg	48.8 Min
YD	ASTM D1838	Corrosion, Copper Strip, 1 hr @ 40°C	1 Max
	AS'IM D1657	Density @ 15°C	Report
	ASIM DŽ713 or A.L.P.G.A.	Dryness	Pass (1)
	ASTM D2163	Mothano, Mole % Odorant (2) (3)	0.25 Max
	ASTM D2163	Olefins, Mole %	Report (5) (6)
表 训	A.L.P.G.A.	Residue on Evaporation, mg/1	20 Max
	A5'INI D2784	Sulphur, Total, µg/g	185 Max
rei	ASTM D1267	Vapour Pressure, kPa @ 40°C	1530 Max
IJ.	ASTNI D1837	95% Volume Evaporation, °C	-38 Max (4)
6.4		<u> </u>	

		- 1.1											
MOUNTS	715	+ £	Actions	1177777	A	أستستنا	الاستعادات	ستعد فيستند عديات بم	a. Alle and a second and an an	2.1	Same and the same as		4.
NOTES:	(1)	11.	NO IM	172112	LS	usea	to a	stermine	aryness	, the	product	15	to
		1.0	MAKES M.	السنديدانا	1	وتحداده و	سعانات	Para man	time is g	ومعملة فعاشاتك			www.marforana.com
Service of the servic		UC	GUID.	racioa	ury	y wilei	i the	Treeze	time is o	reater	' than 5	- m11	nures

- (2) Odorant shall be Ethyl Mercaptan, and shall be added in the proportion of 12 mg odorant to each litre of liquefied product.
- (3) W: applicable to supplies to Porta-Gas
- (4) This requirment shall be waived when the butanes and heavier content ASTM D2163 is less than 2.5 mole %.
- (5) Supplies to Porta Gas shall have a propylene content Δ STM D1263 of less than 40 mole %.
- (6) If total olefins are greater than 20%, endorse the certificate that the product is off specification for automotive LPG.

EFFECTIVE DATE: 1 October 1983

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PRODUCT SPECIFICATION BUTANE L.P.G.

M	thod	Test	Specification
Comp	lated from	n Calorific Value, Gross, MJ/kg	47.7 Min
ASIM	01838	Corrosion, Copper Strip, 1 Hr @ 40°C	1 Max
ASTM 1	01657	Density @ 15°C	Report
ASTM 1	02163	Methane, Mole % Olorant (1)	0.25 Max
A.L.P	G.A.	Residue on Evaporation, mg/1	20 Max
ASTM I)2784	Sulphur, Total, ug/g	140 Max
AS'IM I	1267	Vapour Pressure, kPa @ 40°C	520 Max
Visual		Water	No Ertrained Free Water
AS'IM I	01837	95% Evaporated, Volume %, °C	2 Max (2)
NOTES	(1)	Odorant shall be Ethyl Mercaptan and shall be proportion of 12 mg odorant to each litre of product.	added in the liquefied
	(2)	This requirement shall be waived when the percontent - ASTM D2163 - is less than 2.0 mole	tanes and heavid

EFFECTIVE DATE: 1st April 1974

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PRODUCT SPECIFICATION PROPANE/BUTANE L.P.G.

[] }	Method	Test	Specification
	Calculated f Composition A.L.P.G.A.		47.7 Min
	ASTM D1838	Corrosion, Copper Strip, 1 Hr @ 40°C	1 Max
11	ASTM D1657	Density @ 15°C	Report
	ASTM D2713 or Visual	Dryness Odorant (2) (3)	Pass (1)
П	A.L.P.G.A.	Residue on Evaporation, mg/1	20 Max
	ASTM D2784	Sulphur, Total, µg/g	140 Max
M.	ASTM D1267	Vapour Pressure, kPa @ 40°C	355 - 1530
	ASTM D1837	95% Volume Evaporated, °C (4)	2 Max
N	NOTES: (1)	If the vapour pressure is greater than 1240 kPa considered dry when the valve freeze time is grainutes or the product is dry to CoBr test or be	eater than 3
		vapour pressure is equal to or less than 1240 k is considered dry when there is no visible sign free water.	Pa the product
	(2)	Odorant shall be Ethyl Mercaptan and shall be a proportion of 12 mg odorant to each litre of li	dded in the quid product.
	(3)	Not applicable on pipeline transfers to Porta-G	as.
	(4)	This requirement shall be waived when Pentane a ASTM D2163 is 2.0 mole % or less.	nd heavier

EFFECTIVE DATE: 18 November 1978

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PRODUCT SPECIFICATION AUTOMOTIVE DIESEL OIL

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	Method	Test	Specification
	ASTM D974	Acid Number, Strong, mg KOI/g	Ni1
	ASTM D974	Acid Number, Total, mg KOI/g	0.25 Max
Paris .	AS'TM D482	Asn, % mass/mass	0.01 Max
[3])	ASTM D524	Carbon Residue, Ramsbottom on 10% bottoms, % mass/mass	0.2 Max
K ^{oo} N.	ASTM D976	Cetane Index, Calculated	47 Min
	ASTM D2500	Cloud Point, °C	S.Q1d(6) N.Q1d(6)
		Winter (a)	-1 Max +2 Max
rə T		Intermediate (1)	+3 Max +4 Max
ł #		Summer (1)	+3 Max +6 Max
13	ASTM D1500	Colour, ASTM	2 Max
13	ASTM D130	Corrosion, Copper Strip, 3 Hrs @ 100	O°C 2A Mix
13	ASTM D1298	Density at 15°C	0.815 - 0.860
11	ASTM D86	Distillation 90% Recovered, °C	357 Max
10	ASTM 93	Flash Point, PMCC, °C	62 Min
13	AS'M D2274	Insolubles, Accelerated Stability mg/l Mercaptan Factor	25 Max 80 Max (2)(3)
1-3	ASTM 2785 (5)	Sulphur, Total, % mass/mass	0.5 Max
1	ASTM D445	Viscosity, Kinematic mm ² /s at 40°C	2.04 - 5.64
13	ASTM D1796	Water and Sediment, Volume %	0.05 Max (4)

NOTES: (1) Winter Grade : For delivery between 1/4 and 31/8
Intermediate Grade : For delivery between 1/3 and 31/3, and
between 1/9 and 31/10
Summer Grade : For delivery between 1/11 and 29/2

- (2) This test not applicable to 100% straight run material.
- (3) Mercaptan factor is equivalent to total mercaptan sulphur as $\mu g/g$ S (ASIM D1323) plus ten times the caustic extractable mercaptans as $\mu i/g$ S (Mobil Method No. 524).
- (4) For this test, solvent shall be toluene, no demulsifier shall be used, and bath temperature shall be 49 \pm 1°C.
- (5) Alternatively, an X-ray fluorescence test method may be used.
- (6) N. Qld : Port Alma and all ports north.
 S. Qld : All other installations not defined as N. Qld.

EFFECTIVE DATE: 1 October 1984

PRODUCT SPECIFICATION INDUSTRIAL DIESEL OIL

F a	Method	Test	Specification
	AS'IM D974	Acid Number, Strong mg KOI/g	Ni.1
[3	AS'IM D974	Acid Number, Total, mg KOI/g	0.25 Max
	ASTM D482	Ash % Mass/Mass	0.01 Max
V.)	ASIM D524	Carbon Residue, Ramsbottom, % Mass/M	ass 0.15 Mux
[] 	ASTM D976	Cotane Index, Calculated	40 Min
eren.	ASTM D1500	Colour, ASTM	2.5 - 8.0
[]	ASTM D130	Corrosion Copper Strip, 3 Hrs @ 100°	C 2A Max
	ASTM D1298	Density 0 15°C	0.816 - 0.876
	AS'IM D93	Flash Point, PMCC, °C	66 Mi.n
	AS'IM 97	Pour Point, °C Winter (1) Swmmer (2)	0 Max 3 Max
	ASTM D2785 (2)	Sulphur, Total, % Mass/Mass	0.5 Max
	ASTM D445	Viscosity, Kinematic nun2/s @ 40°C	2.040 - 7.200
	ASTM D1796	Water and Sediment, Volume %	0.10 Max (3)

NOTES (1) Winter Grade: For Delivery between 1 - 4 and 15 - 9 Summer Grade: For Delivery between 16- 9 and 31 - 3

- (2) Alternatively, an X-ray fluorescent test may be used
- (3) For this test, Solvent shall be toluene, no demulsifier shall be used, and bath temperature shall be 49 \pm $1\,^{\circ}\text{C}$

EFFECTIVE DATE: October 16, 1979

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PRODUCT SPECIFICATION RAILWAY DIESEL OIL

Method	Test	Specification
Calculated (1)	Calorific Value, Gross, NJ/kg	43.5 Min
ASTM D976	Cetane Index, calculated	50 Min
ASTM D2500 .	Cloud Point, °C	-4 Max
ASTM D1500	Colour, ASTM	2 Max
ASTM D1298	Density at 15°C	0.815 - 0.860
AS'IM D86	Distillation	
	90% Recovered, C	343 Nnx
원 시민국의 기교회 (1200년) 전 120년 1207년 - 120년 - 120년 120년 120년 120년 120년 120년 120년 120년	Recovery, Volume %	97.5 Min
ASTM D93 ASTM D97	Flash Point, PMCC, °C Pour Point, °C	66 Min -9 Max
ASTM D2785 (2)	Sulphur, Total, % mass/mass	0.25 Max
ASTM D445	Viscosity, Kinematic, mm ² /s	2.0 - 5.0
ASTM D1706	Water and Sediment, Volume %	0.1 Max

NOTES: (1) See Nomograph for values. The reference for the nomograph is API Data Book, Figure 14A1.1.

(2) Alternatively, an X-ray fluorescence test method may be used.

EFFECTIVE DATE: 1 April 1974

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PRODUCT SPECIFICATION INDUSTRIAL FUEL OIL: LOW SULPHUR GRADE

Me thod		Test	Specification
ASTM D482 (1)	Ash, & Mass/Mass	0.1 Max
Calculated (2)	Calorific Value, Gross MJ/kg	42.1 Min
Mobile 1006	(3)	Caompatibility, Volume %	0.3 Max
AS'TM D1298		Density @ 15°C	0.990 Max
ASTM D93		Flash Point, PMCC, °C	66 Min
ASTM D97		Pour Point, Upper, °C	24 Max
ASIM D473		Sediment by Extraction, % Mass/Mass	0.15 Max
X-ray		Sulphur, Total, & Mass/Mass	0.5 Max
ASTM D445		Viscosity, Kinematic, mm ² /s@ 50°C	80 Max
ASTM D95		Water by Distillation, Volume %	0.75 Max
NOTES:	(1)	For fuel oils containing waste lubricating according to ASTM D1548 sections 8.1 to 8.5 determined. A maximum of 0.15% mass/mass s This specification does not waiver the ASTM ment. The sulphated ash requirement does material supplied to BP and Sholl.	shall be hall apply. 1482 require-
	(2)	Ampol nomograph based on API Data Book figureshall be used.	re 14 A1 - 2
	(3)	Compatibility is based on the volume precip	itated by a
		30% dilution of fuel oil with a straight ru The reading is "as found" not adjusted for specification is applicable to product supp only.	dilution. Thi

EFFECTIVE DATE: 1 August, 1984

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PRODUCT SPECIFICATION INDUSTRIAL FUEL OIL

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Method	nod Test	
ASTM L482 (1)	Ash, % Mass/Mass	0.1 Max
Calculated (2)	Calorific Value, Gross MJ/kg	42.1 Min
Mobil 1006 (3)	Compatibility, Volume %	0.3 Max
ASTM 1298	Density @ 15°C	0.990 Max
ASTM D93	Flash Point, PMCC, °C	66 Min
AA	Load, mg/kg	200 Max (1)
ASTM D97	Pour Point, Upper, °C	15 Max
AS'IM D473	Sediment by Extraction, % Mass/Mass	0.15 Max
Y-ray	Sulphur Total, % Mass/Mass	3.0 Max
ASIM D445	Viscosity, Kinematic, mm ² /s @ 50°C	80 Max
ASTM D95 (4)	Water by Distillation, Volume %	0.75 Max

NOTES: (1) For fuel oils containing waste lubricating oils ash according to ASTM D1548 sections 8.1 to 8.5 shall be determined. The lead content of the fuel oil shall be determined on this ash by AA Spectrometry.

- (2) Nomograph based on API Data Book figure 14 A1 2 shall be used.
- (3) Compatibility is based on the volume precipitated by a 30% dilution of fuel oil with a straight run diesel solvent. The reading is "as found" not adjusted for dilution. This specification is applicable to product supplied to Mobil only.
- (4) A 2 ml water trap shall be used with 100 ml of sample.

PRODUCT SPECIFICATION BUNKER FUEL OIL

Method	Test	Specification
ASTM D482	Ash, % mass/mass	0.15 Max
Mobil 1006 (1)	Compatibility, Volume %	0.3 Max
ASTM D1298	Density @ 15°C	Report
ASTM D93	Flash Point, PMCC, °C	66 Min
ASTM D97	Pour Point, upper,°C	Report
ASIM D473	Sediment by Extraction, % mass/mass	0.15 Max
X-ray	Sulphur, % mass/mass	3.5 Max
ASTM D445	Viscosity, Kinematic, nm ² /s @ 50°C	315 Max
ASTM D95 (2)	Water by Distillation, Volume %	1.0 Max

NOTES: (1) Compatibility is based on the volume precipitated by a 30% dilution of free oil with a straight run diesel solvent. The reading is "as found" not adjusted for dilution. This specification is applicable to product supplied to Mobil only.

(2) Λ 2 ml water trap shall be used with 100 ml of sample.

EFFECTIVE DATE: 16 October, 1979

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PRODUCT SPECIFICATION POWER KEROSINE

Method	Test	Specification
ASIM D974	Acid Number, Total, mg KO1/g	0.05 Max
IP 17B	Colour Lovibond	1.5 Max
ASTM D130	Corrosion, Copper Strip, 3 hrs @ 50°C	1 Max
ASTM D1298	Density @ 15°C	0.790 - 0.850
ASTM D86	Distillation - 10% Recovered, °C - 70% Recovered, °C - 94% Recovered, °C - 95% Recovered, °C - Final Boiling Point, °C	160 Max (1) 200 Max 210 Min (1) 245 Max (1) 275 Max
IP 170	Flash Point, Abol °C	32 Min
ASTM D381	Gum, Existent, mg/1	20 Max
ASTM D2700	Octane Number, Motor	54.0 Min
IP 104B	Sulphur, Mercaptan, µg/g	20 Max
ASTM D2785 (2)	Sulphur, Total % mass/mass	0.25 Max

NOTES: (1) Power kerosine must meet Customs' requirements on distillation, as specified above and must also pass the following Customs burning test:

- the oil shall not burn with a bright luminous, not smoky, steady flame for one hour, when subjected to a burning test in an ora nary wick lamp in which recognised brands of lighting k rosine burn satisfactorily. -
- (2) Alternatively, an X-ray fluorescence test method may be used.

EFFECTIVE DATE: 1 October 1983

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PRODUCT SPECIFICATION LIGHTING KEROSINE

Method	Test	Specification
IP 10	Burning Test	Satisfactory (1)
	Wick Char µg/g	10 Max
IP 17B	Colour, Lovibond	1. Max
ASTM D130	Corrosion, Copper Strip 2 Hrs @ 100°C	1 Max
ASTM D1298	Density 0 15°C	Report
ASTM D86	Distillation, 20% Recovered, °C Final Boiling Point, °C	200 Max 300 Max
TP 30	Doctor Test	Negative (2)
IP 170	Flash Point, Abel, °C	38 Min
ASIM D1322	Smoke Point	24 Min
ASTM D2785 (3)	Sulphur, Total, Max %	0.05 Max

NOTES: (1) The result of the burning test shall be considered satisfac ory when:

- (a) the flame is not smoky; and is no more than 12 mm lower in height at the end of the test
- (b) the wick shall have no appreciable hard incrustation
- and (c) the final condition of the chimney shall be clean, with no more than a slight cloudy deposit.
- (2) Alternatively, Mercaptan Sulphur (IP1048 or ASTM D3227) 30 µg S/g maximum may apply.
- (3) Alternatively, an X-ray fluorescence test method may be used.

EFFECTIVE DATE: 1 January 1983

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PRODUCT SPECIFICATION AVIATION CASOLINE 100/130

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	Method	Test	Specification
	» - «ماهانسانها عمله باینامانساد رسیده بینیانسانسانسانسانسانسانسانسان	Additives	Report type and quantity (1)
	ASTM D611	Aniline Point	Report
	ASTN: D611 + ASTM D1298	Aniline Gravity Product	7500 Min
	Visual	Appearance	Clear, bright and free from sediment, suspend- ed matter, and undissolv- ed water at temperature of delivery.
Ł	9 P. C	Colour	Green
	Visual IP 17A	Colour Lovibond (50 mm cell)	Blue 1.7 - 2.9 (2) Yellow 1.5-2.7 (3)
er en	ASTM D130	Corrosion, Copper Strip 2 Hrs @ 100	0°C 1 Max
	ASTM D1298	Density @ 15°C	Report
	ASTM D86	Distillation - 10% Evaporated, °C - 40% Evaporated, °C - 50% Evaporated, °C - 90% Evaporated, °C - F.B.P. , °C - 10% Evap.+50% Evap Residue, Vol % - Loss, Vol %	75 Max 75 Min 105 Max 135 Max 170 Max , °C 135 Min 1.5 Max 1.5 Max
	IP 16	Freezing Point, °C	-60 Nux
	ASTM D1298	Gravity, "API	Report
	ASTM D381	Gum, Existant, mg/1	30 Mix
	ASTM D2700	Knock Value Motor Octane Number Octane Number, Lean	99 Min 100 Min
	AS'IN D3341	Lead, gPb/1 (5)	0.841 Nax
	ASTM D909	Performance Number, Rich	130 Min
4 3	ASTM D2785	Sulphur, Total, % Mass	0.05 Max
	ASTM D323	Vapour Pressure, Reid, kPa (6)	38 - 48.25
	ASTM D1094	Water Reaction Volume Change, mI Interface Rating Separation	2 Max 2 Max 2 Nax

NOTES: (1) Anti Oxidant shall be: N, N¹-disecondary-butyl-para-phenylenediamine and shall be added at the rate of 19.1 to 24.0 mg/l of Avgas.

EFFECTIVE DATE: 10 November 1979

⁽²⁾ Blue dye shall be 1,4 dialkylaminoanthraquinone and shall be added at the rate of 0.713 to 1.242 mg/l of Avgas.

⁽³⁾ Yellow dye shall be p-diethylaminoazobenzene and shall be added at the rate of 0.900 to 1.852 mg/l of Avgas.

⁽⁴⁾ ASTM D86 Group 2 distillation shall apply.

⁽⁵⁾ Alternatively an X-ray Fluorescent Method may be used.

⁽⁶⁾ ASTM 1323 Para 16 conditions shall apply.

PRODUCT SPECIFICATION AVIATION TURBINE FUEL

1.3	Method	Test	Specification
(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	IP 273	Acidity, Total; mg KON/g Addivitives	0.012 Max Nil (1)
	ASTM DG11	Aniline Point, °F	Report
	ASTM D1298	VbIo	Report
	ASTMD611 & ASTMD12	298 Aniline Gravity Product	5250 Min
(7)	Visual	Appearance	Clear, Bright and Free from
f.)			Sediment, suspended Matter and Undissolved water at temperature of delivery
	ASTM D1319	Aromatics, Vol %	20 Max
	ASTM D512	Chloride, mg/1 NaC1	0.15 Max (2)
	IP 17B	Colour Lovibond	4 max
	AS'IM D130	Corrosion, Copper Strip, 2Hrs @	
17	IP 227	Corrosion, Silver Strip, 411rs @	
ł i	ASTM D1298	Density @ 15°C	0.775 to 0.830
	ASTM D86	Distillation (3) Initial Boiling Point 10% Recovered, °C 20% Recovered, °C	Report 204 Max 200 Max
		50% Recovered, °C 90% Recovered, °C Final Boiling Point, °C Residue, Vol % loss, Vol %	Report Report 300 Mix 1.5 Mix
na 111. Sana Pagada ataun	IP 30	Doctor Test	1.5 Mix
l d	IP 170	Flash Point, Abel, °C	Negative (4)
	IP 16	Freezing Point, °C	38 Min
	ASIM D381	Gum Existant, mg/1	-50 Max 70 Max
	AS'IM D1840	Naphthalenes, Vol %	
	ASTM D1319	Olefins, Vol %	3.0 Mix (5)
	ASTM D1322	Smoke Point	5 Max
	Atomic Absorption	Sodium mg/1 Na	20 Min (5)
11	ÎP 204	Sulphur, Mercaptan, Mass %	0.05 Mix (2)
	ASTM D2785	Sulphur, Total, Mass %	0.001 Max (4)
	ASTM D3241	Thermal Stability, JFTOT Filter AP,mm Hg Visual Deposit Rating ASTM Co Visual Code Rating Spun Deposit Rating Spot Deposit Rating	No "Peacock" (6) Report
	ASTM D445	Viscosity, Kinematic, mm ² /s @ -2	Report
	ASTM D1094	Water Reaction Interface Rating	0°C 8 Max (7) 1b Max
	AS'IM D2550	Separation Rating	2 Max
	ASIM DZ550	Water Separometer Index, Modifed	85 Min

AVIATION TURBINE FUEL

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and the second second										
NOTES:	(1)	The product	abatt	MARKET W	44.34	مستناه الماسية	Add as assessed		Language 1 Street Committee	. 4. 5
110.11111	(4)	The product	PHULL	POULTITIE	HO	additives.	Mineral	acia	contamin	ation
		shall be te	ntal n	المساد المنتشرين	4	ACOUNT TOOLS				
		SHULL DE LE	SICUL ill	LUIUINO	uo	AS INC 1974				

- (2) Chloride results greater than 0.15 mg/l NaCl or Sodium results greater than 0.05 mg/l Na shall be notified to DQA Queensland Field Office.
- (3) Group 4 conditions with a bath temperature 0 4°C shall apply.
- (4) Either Doctor Test Negative or Sulphur Mercaptan 0.003 S Mass % maximum shall apply. For Release to DEF (AUST) 5208, Sulphur Mercaptan above 0.001 S Mass % requires that Production Permit QFO 80/1 be cited.
- (5) Nephthalene Vol % of 3.0 max required for QTA release if smoke point is between 20 and 24 inclusive. For DEF (AUST) 5208 a smoke point of 19 is satisfactory and no correction for pressure is required.
- (6) Abnormal colour requires retesting at 270°C for DEF (AUST) 5208 release.
- (7) Amendment to DEF (AUST) 5208 allows a -20°C Viscosity of 8 Max as an alternative to Viscosity at -34.4°C, authorization refer to telex QC 060/DQA, 5 June 1980.
- (8) Copper Content is not required with the present Ampol Refinery processes.
- (9) DEF (AUST) 5208 or QTA 1K/80 specification or both shall be used for release.

EFFECTIVE DATE: 1 August 1980

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PRODUCT SPECIFICATION LIGHT STRAIGHT RUN NAPHTHA

Method	Test	Specification
ASTM D1298	Density @ 15°C	Report
ASTM D86	Distillation 95% Evaporated, °C	90 Max
ASTM D323	Reid Vapour Pressure, kPa	69 - 104
ASTM D2785	Sulphur, Total, µg/g	30 Max

EFFECTIVE DATE:

1 April 1974

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PRODUCT SPECIFICATION INDUSTRIAL TOLUENE

Nethod	Test	Specification
ASIM D847	Acidity	0.334 mg NaOH/1 Max
ASTM D611	Aniline Point, Mixed °C	12 Max
Visual	Appearance	Pass (1)
ASTM D848	Colour, Acid Wash	4 Max
IP 17Λ	Colour, Lovibond, 457 mm cell	Red 0.2 Max Yellow 2.0 Max Blue 0.0 Max Brightness 0.2 Max
ASTM D1.30	Corrosion, Copper Strip 30 Minutes @ 100°C	2 Max
ASTM 1)850	Distillation Range, °C	2° Max to dry point, including 110.6 (2)
ASTM D1298	Density @ 15°C	Report
ASTM D1296	Odour	Salcable

NOTE: (1) Clear and bright at room temperature

(2) For Sale to Shell 1°C Max. including 110.6

EFFECTIVE DATE: 1 January 1985

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PRODUCT SPECIFICATION MINERAL TURPENTINE

Method	Test	Specification
ASTM D974	Acid Number, Strong	Ni.1
ASTM D611	Aniline Point, °C	20 - 25
Visual	Appearance	Pass (1)
IP 17A	Colour, Lovibond, 457 mm cell	C.O Red + 3.0 Yellow + 0.0 Blue + 0.0 Brightness Max
ASIM D130	Corrosion, Copper Strip, 311r @ 50°C	1 Max
ASTM D1298	Density @ 15°C	Report
ASTM D86	Distillation - IBP °C - 10% Evaporated, °C - 50% Evaporated, °C - 95% Evaporated, °C - F.B.P. °C	145 - 155 150 - 160 160 - 170 180 - 190 200 Max
IP 170	Flash Point, Abel, °C	32 Min
AS'IM D1296	Odour	Saleable
Aust.Std.K.8.1 and K8.2 appendix H	Pheno1, μg/g	300 Max
ASTM D1353	Residue on Evaporation, mg/1	200 Max

NOTE: (1) Clear, bright and free from sediment, suspended matter, and undissolved water at temperature of delivery.

EFFECTIVE DATE: 13 December 1974

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PRODUCT SPECIFICATION WHITE SPIRIT

Nethod	Test	Specification
ASTM D974	Acid Number, Strong	Ni.1
ASTM D611	Aniline Point, °C	50 - 56
Visual	Appearance	Pass (1)
IP 17A	Colour, Lovibond, 457 nm cell	0.0 Red + 3.0 Yellow + 0.0 Blue + 0.0 Brightness Max
ASTM D130	Corrosion, Copper Strip 3Nr 0 50°C	1 Mux
AS'IM D1.298	Density @ 15°C	Report
AETM D86	Distillation - IBP °C - 10% Evaporated °C - 50% Evaporated °C - 95% Evaporated °C F.B.P. °C	145 - 155 150 - 160 160 - 170 180 - 190 200 Max
IP 170	Flash Point, Abel, °C	32 Min
ASTM D1296	Odour	Saleable
Aust.Std.K8.1 and K8.2 Appendix H	Phenol, μg/g	300 Max

NOTE: (1) Crear, bright, and free from sediment, suspended matter, and undissolved water at temperature of delivery.

EFFECTIVE DATE: 13 December 1974

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PRODUCT SPECIFICATION SOLVENT 143

Method	Test	Specification
ASTM D611	Aniline Point, °C	57 Max
Vi.sua1	Appearance	Pass (1)
ASTM D2600	Benzene, % Volume	1.0 Max
IP 17A	Colour, Lovibond, Mux 457 mm cell	0.2 Red + 2.0 Yellow + 0.0 Blue + 0.2 Brightness
ASTM D130	Corrosion, Copper Strip 3 hr @ 50°C	1A Max
ASTM D1298	Density 0 15°C	Report
ASIM D86	Distillation - IBP °C 10% Evaporated, °C 50% Evaporated, °C 90% Evaporated, °C E.P.	51 Min 71 - 79 90 - 98 113 - 121 135 Max (2)
ASTM D1296	Odour	Saleable
Aust.Std.K8.1 and K8.2 Appendix H	Pheno1s, µg/g	300 Nnx

NOTE: (1) Clear, bright, and free from sediment, suspended matter and undissolved water at temperature of delivery.

(2) Dry point.

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APPENDIX B
CALTEX TYPICAL PROPERTIES

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APPENDIX B

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CALTEX TYPICAL PROPERTIES

PETROL	SYDNE Ninety Two	Super	ADELA Std.	IDE Super
Distribution O.N.	Not normall	y conducted	(* * * * * * * * * * * * * * * * * * * 	<u></u>
Reid Vapour Press (Seasonal)	Not determined in lieu of F.V.I.			
10% Rcc. 50% 90% EP	46 92 160 204	47 95 160 205	50 84 145 175	48 95 145 185
S Total % Mass	0.015	0.015	0.0005	0.000
S Mercaptan mg/kg	4	5		
Automotive Diesel Oil				
Cetane Index Flash Pt Cloud Pt. Ap 15 to Sep 15 Sep 16 to Ap 14	47 85 -1 +4		\$ 10 4	5 1
50% Rec. 90% Rec Vis. cS @ 40°C Density @ 115°C Sulphur % Mass	0			0 3.5 0 0.10
Fuel Oil	(K94)	0)		
Density kg/1 Flash Point Pour Pt.	95 12	$oxed{10}$. The problem of $oxed{10}$ and		.0 .0
Viscosity cS @ 50 C Sulphur % Mass	20 to 150 60 2.2 3.		0 3.0	

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APPENDIX C

NOBIL DISTILLATION PROPERTIES

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APPENDIX C

MOBIL DISTILLATION PROPERTIES

Premium Petrol (RON 97)

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	Sunmer	Winter
10% Evaporation	65° C	60°C
50% Evaporation	115° C	112° C
90% Evaporation	183° C	180°C
Final Boiling point	~ 225°C	~ 225°C

APPENDIX D

BHP LPG SPECIFICATIONS

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APPENDIX D

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BHP LPG SPECIFICATIONS

Commercial Propane Specification	Typical Analysis
Ethane mol % 2.5 maximum Propane mol % 95 minimum Butane mol % 3 maximum C5 + mol % 0.2 maximum Total Sulphur ppm (by wt) 80 maximum Water Content Pass NGPA Dewpoin	
method test	Dry
Vapour Pressure KPA Gauge at 40 Deg°C	1340
Corrosive Compound Copper strip No.	1 Pass
Conmercial Butane	
Ethane mol % N/A Propane mol % 4 maximum Butane mol % 95 minimum C5 4 mol % 3 maximum Total Sulphur ppm (by wt) 80 maximum Water Content No free water by visual inspection	1.4 97.0 1.6 25. Pass
Vapour KPA Gauge at 40 Deg°C 520	360
Corrosive Compounds Copper strip No. 1	Pass

Other general properties include: (i) < 0.1 mol% olefins in both propane and butane (ii) residues on evaporation for propane 0.5 - 1.0 mg/100 ml and (iii) iso: normal ratio of 0.7 - 0.8 for butane.

1/1/304 11-09-0940

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August, 1985

SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY

AMDEL Report

No. 1568

REVIEW OF PETROLEUM PRODUCTS SPECIFICATIONS VOLUME II

Ву

J.R. Tuffley

Investigated by: Operations Division

Manager, Operations Division: Peter M. Cameron

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES
Flemington Street, Frewville, South Australia, 5063

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1. PETROL STANDARDS

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AS'IM D 439 (1983) - Automative gasoline

BS 4040 (1978) - Petrol (gasoline) for motor vehicles

AS 1876 - Petrol (gasoline) for motor vehicles

(1982) - Part 1 - Leaded petrol

(1984) - Part 2 - Unleaded petrol

2. LPG STANDARDS

ASTM D1835 (1982) - Liquefied Petroleum Gases

BS 4250 (1975) - Commercial butane and propane

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Specifications and test methods

ALPGA and AIP (1985) - Interim specification for automotive LPG

3. AUTONOTIVE DISTILLATE AND FUEL OIL STANDARDS

ASTM D 396 (1980) - Fuel oils

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BS 2869 (1983) · Fuel oils for oil engines and burners for

non-marine use.

AIP Techdata sheet 15 - Automotive diesel fuel storage and handling

FOREWORD

This Report is presented in two volumes:

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VOLUME I contains a discussion of the various standards and items of legislation, and a summary of the main parameters in tabular form.

VOLUME II is a reference volume containing complete copies of the actual standards referred to in Volume I.

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Standard Specification for **AUTOMOTIVE GASOLINE**

This standard is issued under the fixed designation D 439; the number immediately following the designation indicates the veri of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reprised in the case of the year of last revision or reapproval. A superscript epsilon (c) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1.1 This specification is for guidance in establishing the required properties of automo-are gasolines for ground vehicles, 1.2 This specification is not a complete def-

million of gasoline. It describes various characteristics of gasolines used in a wide range of operating conditions. It does not necessarily include all types of gasolines satisfactory for automotive vehicles, nor necessarily exclude gasolines that may give unsatisfactory performince in certain equipment or under certain operating conditions.

1. Applicable Documents

- 2.1 ASTM Standards:
- D86 Method for Distillation of Petroleum
- D130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test²
 D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)²
- D381 Test Method for Existent Gum in Fuels by Jet Evaporation²
- D325 Test Method for Oxidation Stability of Casoline (Induction Period Method)²
 D1266 Test Method for Sulfur in Petroleum
- Products (Lamp Method)2 D2533 Test Method for Vapor-Liquid Ratio
- of Gasoline³
 D2547 Test Method for Lead in Gasoline
 Volumetric Chromate Method³
 D2551 Test Method for Vapor Pressure of
- Petroleum Products (Micromethod) D2599 Test Method for Lead in Gasoline by X-Ray Spectrometry3

- D 2622 Test Method for Sulfur in Petroleum Products (X-Ray Spectrographic Method)3
- D 2699 Test Method for Knock Characteristics of Motor Fuels by the Research Method4
- D 2700 Test Method for Knock Characteristics of Motor and Aviation Fuels by the Motor Meti. rd
- D 2885 Test Method for Research and Motor Method Octane Ratings Using On-Line Analyzers4
- D3116 Test Method for Trace Amounts of Lead in Clasolines
- D3229 Test Method for Low Levels of Lead
- in Gasoline by X-Ray Spectrometry'
 D 3231 Test Method for Phosphorous in Gasoline⁵
- D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectrometrys
- D 3341 Test Method for Lead in Gasoline-Iodine Monochloride Methods

3. General

3.1 This specification provides for an automatic variation by the seller to meet the requirements of seasonal changes in temperature, depending upon the season and the locality in which the product is to be used. This is done by providing five volatility classes and differ-

¹ This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.0A on Gasoline.

Current edition approved Oct. 28, 1983. Published January 1984. Originally published as D 439 – 37 T. Last previous edition D 439 – 82a.

² Annual Book of ASTAI Standards, Vol 05.01.

³ Annual Book of ASTAI Standards, Vol 05.02.

⁴ Annual Book of ASTAI Standards, Vol 05.03.

³ Annual Book of ASTAI Standards, Vol 05.03.

unleaded gasolines.

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3.2 This specification represents a description of gasolines as of the date of publication. The specification is under continuous review. which may result in revisions based on changes in gasoline or automotive requirements, or both. All users of this standard, therefore, should refer to the latest edition.

Note—If there is any doubt as to the latest edition of Specification D 439, the user should contact ASTM Headquarters.

4. Detailed Requirements

4.1 The five volutility classes of gasoline shall conform to the requirements prescribed in

4.2 The seasonal and geographical distribution of the five classes shall conform to the schedule in Table 2,

4.3 Antiknock index levels, I fined as the average of the Research octane number (RON) and Motor octane number (MON), and their application are set forth in Table 3.

5. Wörkmanship

5.1 The finished gasoline shall be visually free of undissolved water, sediment, and suspended matter and shall be clear and bright at the amblent temperature or 21°C (70°F), whichever is highe.

6. Basis for Purchase

6.1 The purchasing agency shall: 6.1.1 State the antiknock index as agreed upon with the seller (Table 3).
6.1.2 Indicate the season and locality in

which the fuel is to be used, and,

6.1.3 Indicate the lead level required (Table

7. Test Methods

7.1 The requirements enumerated in this specification shall be determined in accordance D 439

with the following ASTM methods: 7.1.1 Distillation - Method D 86.

7.1.2 Vapor - Liquid

D 2533.

7.1.3 Vapor Pressure—Test Method D 323, or Test Method D2551.

7.1.4 Research Method Octane Number-Test Method D2699 or Test Method D2885.

7.1.5 Motor Method Octune Number-Method D 2700 or Test Method D 2885.

7.1.6 Corrosion-Test Method D 130, 3 h at

J0°C (122°F).
7.1.7 Existent Gum—Test Method D381,
7.1.8 Sulfur—Test Method D1266 or Test Method D 2622.

7.1.9 Lead—Test Method D2547, Test Method D2599, or Test Method D3341. For lead levels below 0.03 g/L (0.1 g/gal) use Test Method D3116, Test Method D3229, or Test Method D 3237.

7,1.10 Oxidation Stability-Test Method

8. Precision

8.1 The following criteria should be used to Judge the acceptability of results (95 % confidence):

8.1.1 Repeatability-Data to determine acceptable limits for duplicate results obtained by the same operator have not been developed.

8.1.2 Reproducibility—The results submitted by each of two laboratories should not be considered suspect unless their difference is greater than the limits shown in the following table:

Average Octane Number (R+M)/2	Limit Octane Number
85	0.7
87	0.7
89	0.6
91	0.6
93	0.6
95	0.6
67	87

8.2 The reproducibility limits in 8.1.2 were calculated from Research and Motor octane number results obtained by 15 to 25 member laboratories of the National Exchange Group (NEG) of Research and Development Division I, ASTM Committee D-2, participating in co-operative testing programs during the period 1966 through 1976.

6 D 439

TABLE 1 Detailed Requirements for Gasoline

	Distillat	ion Tempera	lures, °C (°F),	Dist.	Vapor/Liquid Ratio*			
Gasoline Vol- atility, Class	JÖ mäx	min	50 milk	90 max	End Point.	Res- idue, %, max	Test Tem- perature,	V/L, max
A B C D E	70 (158) 65 (149) 60 (140) 55 (131) 50 (122)	77 (170) 77 (170) 77 (170) 77 (170) 77 (170) 77 (170)	121 (250) 118 (245) 116 (240) 113 (235) 110 (230)	190 (374) 190 (374) 185 (365) 185 (365) 185 (365)	225 (437) 225 (437) 225 (437) 225 (437) 225 (437)	2 2 2 2 2 2	60 (140) 56 (133) 51 (124) 47 (116) 41 (105)	20 20 20 20 20

Clasoline Volatility, Class	Reid Vapor Pressure, kPa (psi), max	Pressure, kPa Strip Cur-		Existent Clum, mg/100 ml., max	Sulfar, w. C., max		Osidation Anti- Stability, knock fr min dex		
		Unleaded*	Leaded .			Un- leaded	Lended		
A B C D E	62 (9.0) 69 (10.0) 79 (11.5) 93 (13.5) 103 (15.0)	0.013 (0.05) 0.013 (0.05) 0.013 (0.05) 0.013 (0.05) 0.013 (0.05)	1.1 (4.2) 1.1 (4.2) 1.1 (4.2) 1.1 (4.2) 1.1 (4.2)	No. 1 No. 1 No. 1 No. 1 No. 1	5 5 5 5 5	0.10 0.10 0.10 0.10 0.10	0.15 0.15 0.15 0.15 0.15	240 240 240 240 240 240	e e e e

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At 101.3 kPa pressure (760 mm Hg).

The intentional addition of lead compounds is not permitted. Current EPA promulgations call for 0.013 g of lead per litre (0.05 g gallon) maximum and 0.0013 g of phosphorus per litre (0.005 g/gallon) maximum, by Test Method D 3231, effective July 1, 5ee Table 3.

Table 2 Schedule of Seasonal and Geographical Volatility Classes

This schedule, subject to agreement between purchaser and seller, represents the time and place of the fuel. Shipments intended for future use may anticipate this schedule.

Where alternative classes are permitted, the option shall be exercised by the seller.

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State	Jan.	Feb.	March	April	May	June	July	Aug.	Sep'.	Oct.	Nov.	Dec.
Alabama	D	D	D/C	C	C	C	C/B	В	B/C	C	C/D	Ď
Alaska	Ħ	E	E	E	E/D	D	D	b .	D/E	E	E	E
Arizona	D	D/C	C/B	В	B/A	Δ	٨	Ņ.	B/C	A/B	B/C D	CAD
Arkansas	E/D	D .	D/C	C	C .	C/B	В	В	BAC	C/D	D .	D/E
California:	44.00	i au	4. 9			es 16.	B	B.	B	B/C	C/D	D/E
North Coast	E/D	D	D	D/C	C	CAB :		B	В	B/C	C/D	D
South Coast	D.	D	D/C	č.	C/B	В	В	Ä	Å	A/B	B/C	C/D
Southeast	D	D/C	C/B	B	B/A	Å B	AB	R	B	B/C	C/D	DIE
Interior	E/D	D.	D	D/C	C/B	В	B/A	A/B	В	B/C	C/D	D/E
Colorado	E	E/D	D/C	Ć.	C/B	Č.	C, DAY	C C	C/D	D'	D/E	E
Connecticut	Ë	E.	E/D	D	D/C	Ċ	č	Č	c'	Č/D	DIE	Ĕ.
Delaware	E	E	EAD	D/C	13/6	Č	è	č	č	CZĎ	D/E	Ë
District of Columbia	E	E/D	D/C	C	è	è	č	Č.	č	č	C/D	ö
7lorida	D	D	DIC	č	è .	č	CAB	B	B/C	č	C/D	Ď
Jeorgia	D	Ď	C	7	č	ç	č	č	ë'	č	Č.	č
lawaii	C E	C E/D	b	bye	CAR	ñ	ñ	ñ	B	B/C	Č,D	DIE
Idaho	15	123.13	U.	DIC	(7)	. "	.,	••	. **	4, 4	4.4	
Illinois.	E	E	E/D	15	DIC	C	C'	C	C	C/D	D/E	E
N 40° Lamude	E	E	E/D	DIC	c'	č	CAB	B/C	è	C/D	b	D/E
5 40' Latitude	E	Ē	EZD	b	byc	è :	č"	۳,۰	Č	CVD	DIE	E
Indiana	Ë	Ë	E/D	D/C	č'	CAB	BIC	Ċ	Č	C/D	D/E	Ē
lowa	Ë	E/D	D/C	č'	C/B	B	В	B	B	B/C	CID	D/E
Kansas	Ë	E/D	b'	Dyc	č'"	ë	Ċ	ë	Č.	C/D	DIE	r.
Kentucky	ช	Ď.	D/C	8	č :	č	C/B	Ď	B/C	C	CID	D
Louisiana	Ĕ	É	E/D	Ď	D/C	è	C.	Ċ.	CAD	Ď	D/E	E
Maine	Ē	ř	EZD	Ď .	D/C	è	č	C	C	CYD	DE	E
Maryland	Ë	i.	EZD	Б	DIC	Č	C	Ĉ.	C/D	D	D/E	E
Massachusetts	Ĕ	Ë	E/D	Ď	D/C	ē	č	C	C/D	D	DIE	E
Michigan	Ë	Ē	E/D	Б	DIC	Č.	Č	è	C	C/D	DIE	E
Minnesota	ö	Ď	D/C	č	Ċ	Ċ	C/8	В	B/C	C	C/D	D
Mississippi	Ĕ	ĔΒ	Ď´	DIC	č	C/B	ũ	В	B/C	C/D	D	D/É
Missouri	Ĕ	E	E/D	DIC	C/B	В	В	В	B/C	C/D	DIE	E
Montana Nebraska	Ē	Ē	E/D	DIC	C/B	В	B	B	В	B/C	C/D	D/E
Neoraska Nevada	•	_	147 12									
N 38º Latitude	ħ.	E D	D	D/C	CAR	В	В	В	В	BIC	C'D	: D/E
S 38º Latitude	ö	D.C	C B	B	B/A	٨	Å	٨	A	A/8	B/C	C/t
New Hampshire	Ĺ	E	E/D	Ď	D/C	C	Ę	C	C/D	D	D/E	E
New Jersey	i.	Ĕ.	E/D	Ď	DIC	Ĉ.	C	Ċ	CAD	b	DIE	E
New Mexico				19.00	, 1870) , 1870)			9.0		4.		400
N 346 Latitude	E/D	Ď	D/C	t'/B	B/A	A	, X	A/18	В	B/C	C/D	D
S 34º Latitude	ö	DC	C/B	B	B/A	Ä.	Á	À	. A/B	B/C	C/D	Ď
New York	Ĕ	ŧ	E/D	D	D/C	Ç	C	C	C/D	b	D/E	Ĕ.
North Catolina	E/D	Ď	D	DIC	C	C	C/B	В	B/C	CAD	D _	D/t
North Dakota	E	E	ED	D	D/C	C/B	В	B	II/C	C/D	DIE	Ë
Ohio	E	E	E/D	b	D/C	C	Ċ	C	C	CAD	D/E	E
Oklahoma	E/b	Ď.	DIC	C	C/B	В	В	В	В.	B/C	CAD	DI
Oregon	7.7		100		11 25 3	100		1.0	da con	44.250	Ele-	
E 122º Longitude	E	E/D	D	b	D/C	C/B	B	В	B/C	CAD	Ď	D/I
W 122° Longitude	Ë	E/D	D	b	D/C	C	C	C	C	C/D	D/E	Ë
Pennsylvania	E	E	E/D	D	D/C	C	Ċ	C	C/D	D	D/E	E
Rhode Island	Ë	E	E/D	D	D/C	C	. .	C	CAD	D	D/E	E
South Carolina	D.	T)	b	DIC	C	C	C/B	B	B/C	CND	D.	D
South Dakota	E	E D	E/D	D/C	C/B	В	В	B	В	B/C	Č\ρ	יונט טוינט
Tennestee	E/D	D .	D	D/C	C	C	C/B	В	B/C	CVD	, D	ווע

TABLE	2	Con	cluded

						******	and the state of				Control of the Control of	The state of the second
State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Texas: E 99° Longitude W 99° Longitude Utah Vermont Virginia	D E E E	D D/C E/D E E/D	D/C C/B D E/D D	C B D/C D	C B/A C/B D/C C	C/B A B C	B A B/A C C	В А А/В С	B A/B C/D C	B/C B/C B/C D C/D	C/D C/D C/D D/E D/E	D D D/E E E
Washington: E 122° Longitude W 122° Longitude West Virginia Wisconsin Wyoming	EEEEE	E E E E	E/D E/D E/D E/D	D D D D	D/C D/C D/C D/C C/B	C/11 C/15 C/15	BCCCB	BCCCB	B/C C C C	C/D C/D C/D C/D B/C	D/E D/E D/E D/E	E E E D/E

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TABLE 3 Gasoline Antiknock Indexes and Their Application

(a	Leaded Clasoline (for vehicles which can or must use leaded gasoline)
Antiknock Index (RON + MON)/2, min ² .	Application
87	Meets annikmeck requirements of most 1971 and lafer model vehicles that can use leaded gasoline and pre-1971 vehicles with low antiknock requirements.
89	Meets antiknock requirements of most 1970 and prior model vehicles that were designed to operate on leaded gasoline, and 1971 and later model vehicles that can use leaded gasoline and have high antiknock requirements.
92	Suitable for most vehicles with very high antiknock requirements that can use leaded gasoline.
and a second propagation and a second second	Unleaded Gasoline (for vehicles which can or must use unleaded gasoline)
Intiknock Index (RON + MON)/2, min	Application
85	For vehicles with low antiknock requirements.
87#	Meets antikhock requirements of most 1971 and later model vehicles.
90	For most 1971 and inter model vehicles with high antiknock requirements.

Reductions for altitude are allowed in accordance with Fig. 1 of Specification D 439. In addition, Motor octane number must not be less than 82.0. Reductions for seasonal variations are allowed in accordance with Fig. 2.



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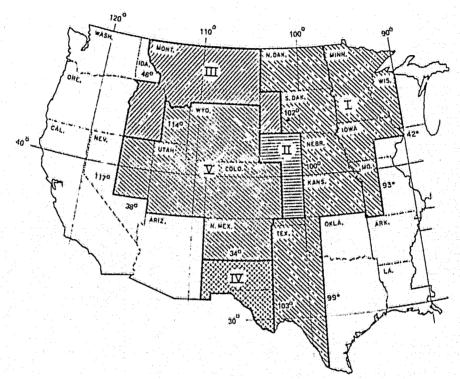


FIG. 1 Antiknock Index Reductions for Altitude.

Antikn	ock fin	det Redu	ctions	by A	lutude	Aten
Area		Less tha	n 89 1		89 or	Greater
1	1000	0.7				0.5
- 11		1.5				1.5
111		2.2				1.5
IV		3.0				2.0

A Reductions also apply to Motor octane number requirement for gasolines with an antikneck index of 87 to 88.9. Current LPA promulgations for unleaded gasoline also regulate the Research octane altitude adjustment. See Annex A1 3.5 for details.



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Specification for

Petrol (gasoline) for motor vehicles

Spécification de l'essence (gazoline) pour automobiles

Spezifikation für Benzin (Gasolin) für Kraftfahrzeuge

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Foreword

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The first edition of this British Standard, published in 1967, was prepared by a representative committee under the authority of the Petroleum Standards Committee in response to a request from the Consumer Council for a standard grading nomenclature to cover grades of petrol* available to the public as motor fuel in the United Kingdom. The grading system adopted was based on the research octane number (FON).

The first revision of the standard, published in 1971, incorporated a revision of the method for determination of RON and gave a fuller treatment of the interpretation of a single RON test result. Four amendments published during the period 1971 to 1976 provided for a progressive reduction in the limiting requirements for lead content.

In this revision, the grading system based on RON is retained to conform to accepted international practice. However, as RON does not adequately represent anti-knock performance, it has been decided to introduce additional grading requirements in terms of motor octane number (MON).

Four grades of petrol, each with a range of octane numbers, are covered by this standard. They are identified by a star system in which the top grade has five stars and the other grades have four, three and two stars respectively.

The fuels covered by this standard are suitable for use in engines designed to comply with Regulations ECE 15 Amendments 01 and 02 of the Economic Commission for Europe (ECE) of the United Nations, and with Directives 70/220/EEC, 74/290EEC and 77/102/EEC of the European Economic Community (EEC), as covered by the Road UK Traffic Act 1972 Sec. 40 (1) and (3) and the Motor Vehicle (Construction and Use) Regulations 1973, as amended.

UK regulations applicable to petrol ungined vehicles are subject to continual review and change in the light of limits set for air quality necessary to protect the environment. The information given in the preceding paragraph, although correct at the time of publication, may therefore become outdated by events; users of the standard are urged to check the appropriate Road Traffic Act (Construction and Use) Regulations and other UK legislation applicable at the time of use.

Since the publication of the first revision and its subsequent amendments, a major review of the standard has led to the incorporation of the following changes in the present revision.

- (a) Introduction of a requirement for MON minima for all grades of petrol.
- (b) Revision of the method for expressing distillation limits in line with current international practice.
- (c) Introduction of minimum limits for evaporation at 70 °C and at 100 °C as part of the specification of volatility.
- (d) Updating of the precision values for RON and introduction of precision values for MON.
- (e) Revision of the limit for existent gum, in accordance with current practice.

- (f) Introduction of a new clause on sampling from petrol pumps and revision of the clause on sampling from storage tanks in the light of experience in the use of the standard.
- (g) Introduction of a minimum limit for lead content.
- (h) Changes in the test methods for several of the requirements resulting from improvements in the relevant national and international standard m. thods.

In view of the agreement reached within the European Economic Community in Directive 78/611/EEC to restrict the maximum lead content of all petrol sold within the Community to 0.40 g/l from 1 January 1981, provision has been made to reduce the corresponding limit in this standard from that date.

It has been found necessary to introduce a *minimum* limit for lead content in order to protect certain engines from valve seat recession. It is stressed, however, that the introduction of this minimum limit for lead content does not imply that the anti-knock quality (as indicated by the minimum RON and MON values) specified in this standard can necessarily be maintained at lead contents below the *maximum* allowable lead content. Owing to the considerable uncertainties surrounding future environmental controls, particularly with regard to lead content, attention is drawn to the fact that any further reduction in this maximum limit would necessitate a complete review and possible revision of the standard

The main purpose of this standard is to provide an indication to the retail buyer of the relative anti-knock qualities of petrols on the market, as defined by RÖN and MON values. It also defines limiting requirements for other essential properties. The quality of marketed petrol may be expected to vary within the limits specified for these properties according to the way in which various aspects of performance, notably road anti-knock performance and volatility, are controlled by each manufacturer or modified for seasonal requirements. Furthermore, both the RON and MON values can vary over a range within each star grade designation. The motorist should be guided by the motor vehicle manufacturers' recommendations on the minimum star grading for petrol for the car concerned.

To allow time for producers to ensure that the quality of petrol at point of sale is in conformity, the standard is effective from 1 February 1979 (but see also 5.2).

Note on testing

In the laboratory testing of petrols against the requirements of clause 5 of this British Standard, it is necessary to use equipment and procedures exactly as laid down in the appropriate test methods. In particular, it is essential to use properly inspected and maintained standard CFR1 engines for the determination of both RON and MON. A useful guide to the satisfactory operation and test precision of a CFR engine can be obtained by including it in the Engine Test Correlation Programme of the Institute of Petroleum. Details of this programme are available from the Institute of Petroleum or the British Standards Institution.

[&]quot;The term 'petrol' is used in this British Standard as being that most generally used by motorists in the UK; 'gasoline' and 'motor spirit' are alternatives.

t Co-operative Fuel Research Committee.

British Standard Specification for

Petrol (gasoline) for motor vehicles

1. Scope

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This British Standard specifies requirements for four grades of petrol that cover the current range of quality retailed in the United Kingdom for use in petrol engine vehicles.

2. References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3. Sampling

3.1 Sampling from storage tanks. For the purposes of this British Standard, all sampling shall be carried out in accordance with the relevant sections of BS 3195: Part 1, and additionally as detailed in 3.2.

3.2 Sampling from petrol pumps

3.2.1 Sampling cans. Standard metric sampling cans are of 5 litres and 1 litre capacity. Their construction shall comply with the appropriate safety requirements for cans that are to hold highly flammable material.

3.2.2 Preparation of cans. A stock of cans shall be kept solely for the purpose of taking petrol samples. N cans shall be rinsed with petrol before being used to remove any residual traces of oil left during manufacturing

operations and then allowed to dry. Before use, all cans shall be checked to ensure they are sound and free from leaks. A petroleum-resistant scaling washer in good condition shall be in position in the cap.

3.2.3 Procedure. From the pump nozzle, 5 litres of petrol shall be carefully drawn into a cool 5 litres can using a clean dry funnel. Immediately afterwards, this sample shall be carefully decanted into the requisite number of 1 litre cans, using a funnel, filling the cans to within 15 mm of the brim. If more than 5 litres are needed, the operation should be repeated immediately and before the pump has been used for any other purpose. The screw caps shall be fully lightened and the cans checked to ensure that there are no leaks.

A quantity of 1 litre is sufficient for the determination of octane numbers and certain other tests, but it is advisable to provide each laboratory with 2 litres of sample in case further work is needed; it is essential that these 2 litres be of identical material.

The sampling procedure shall not be carried out in direct sunlight, if at all possible.

3.2.4 Storage, labelling and transport. Samples should be kept in a cool place although it is not necessary to keep them refrigerated. If left in direct sunlight there is a danger

Table 1. General requirements for all grades of petrol

Property	Lim	T t	Test metho	1
	Min	. Max.	BS reference	Technically equivalent to
Water and suspended matter Distillation	. View	None visible		
Distillate evaporated at 70 °C, % (v/v) Distillate evaporated at 100 °C, % (v/v) Distillate evaporated at 180 °C, % (v/v) Final boiling point, °C Residue, % (v/v)	10 36 90	70) 4349*	IP 123/78
Copper corrosion, 3 h at 50 °C		class 1	4351*	IP 154/78
Sulphur content, % (m/m)		0.2	4350	IP 107/73
Existent gum (solvent washed), mg/100 ml		5	4348	IP 131/77
Oxidation stability, min.	240		4347	1P 40/74
Lead content, g/l (see also 5,2)	0.0	5 0.45	5657	ASTM D3341-74

^{*}Revision in course of preparation. Pending publication of the British Standard the technically equivalent method quoted should be used.

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that the cans will 'balloon'.

Where appropriate, samples should be sealed and marked in compliance with local requirements. Full and legible information relating to the source of the sample shall be attached to the can in such a manner that it will not easily become detached subsequently.

NOTE. If the sample has to be sent to the laboratory by public transport it will be necessary to comply with the general regulations covering transportion of flammable materials and with the requirements of the transport authority concerned, information on the appropriate procedures and type of packaging required should be obtained from the transport authority involved.

4. Composition

The petrol shall consist essentially of volatile hydrocarbons together with additives as required.

5. Requirements

- 5.1 General requirements. When tested in accordance with the methods indicated in table 1 the petrol shall comply with the limiting requirements specified.
- 5.2 Future reduction of limit for maximum lead content. With effect from 1 January 1981 the maximum limit for lead content given in table 1 shall be reduced from 0.45 g/l to 0.40 g/l.
- 5.3 Anti-knock requirements. When determined by the methods referred to in BS 2638 and BS 2637, the anti-knock values of the petrol, expressed as both RON and MON respectively, shall be not less than the minimum values given in table 2 for the grade concerned. (See note on testing in foreword.)

The interpretation of single RON and MON test results by BS 4306 is described in 5.4.

NOTE. The details of procedure and equipment for the determination of RON and MON are given in ASTM D2699-75: IP 237/69 and ASTM D2700-75: IP 236/69* respectively, to which the corresponding British Standards above refer.

Table 2. Anti-knock values for all grades of petrol

Grade designation	RON	MON
5 star	100.0 mm.	86.0 min.
4 star	97.0 mm.	86.0 min.
3 star	94.0 mm.	82.0 min
2 star	90.0 mm.	80.0 min.

5.4 Interpretation of single RON and MON test results: testing margin at the recipient. A recipient who has no other source of information on the true value of a characteristic than a single result should consider that the product fails the specification limit, with 95 % confidence, only if the result X is such that:

$$X < A - \frac{0.84R}{\sqrt{2}}$$

where

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R is the reproducibility of the test method (see 5.5)
A is the minimum RON or MON for the grade.

5.5 Reproducibility of RON and MON. Reproducibility is a quantitative expression of the random error associated with operators working in different laboratories, each obtaining a single result on a portion of the same sample. It is the difference between two such single and independent results that would be exceeded in the long run in only one case in twenty in the normal and correct operation of the test method. (This is known as the 95 % probability level.)

Extensive data obtained from consumer and producer laboratories over a number of years for many samples of conventional petrols have shown that the reproducibility of fuel ratings between laboratories varies with octane number level. The reproducibility of the test methods at intervals of 1 RON and 1 MON over the range required by this British Standard are given in tables 3 and 4.

Table 3. Reproducibility of RON test method

RON	Reproducibility, #
90	0.7
91	0.7
92	0.7
93	0.6
94	0.6
95	0.6
96	0.6
97	0.6
98	0.7
99	0.7
100	0.7

NOTE. Table 3 has been calculated from the reproducibility data published in ASTM D2699-75 : IP 237/69, Section 14.1.2.

Table 4. Reproducibility of MON test method

MON	Reproducibility, 7
80 81	1.2 1.2
82 83	1.2 1.1
84 85	
86	

NOTE. Table 4 has been calculated from the reproducibility data published in ASTM D2700-75 : IP 236/69, Section 14.1.2.

5.6 Disputes. In cases of dispute the procedure detailed in BS 4306 shall be employed.

6. Marking and labelling

6.1 Specification of stars. The grade designations used in connection with this British Standard shall be of the

^{*}Copies of these methods are available for reference in the Library of the British Standards Institution. The methods are published in the *ASTM Annual Book of Standards', Part 47 'Test methods for rating motor, diesel, aviation fuels' and may be purchased in the UK from the Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR or ordered through the Sales Department, British Standards Institution.

general form shown in figures 1, 2 and 3. It is recommended that each star be not less than 40 mm and not more than 80 mm in diameter (point to point) and that the colour used for the design and lettering should be in clear contrast to the background colour.

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- 6.2 Marking of pumps and containers. The following information shall be marked on each dispensing pump or container used for delivering petrol complying with the requirements of this British Standard into the consuming vehicle.
 - (a) The name or mark of the supplier or the vendor of the petrol.
 - (b) The appropriate number of stars, in accordance with 6.1, for the grade of petrol delivered, each star to incorporate the number of this British Standard, i.e. BS 4040.

NOTE. For the marking of blending pumps, see 7.2.

6.3 Associated documentation. In documents relating to the sale or delivery of petrol complying with the requirements of this British Standard, the grade designation in accordance with 6.2 (b) may be expressed in writing, e.g. '4 star' or 'four star', but this form shall not be used on a pump or container.

7. Blending pumps

7.1 General. For the purposes of this British Standard, a blending pump is a device in which two petrols of different grade designation are combined, by a means which is either preset or under the control of the pump operator, into one, two or more blends for delivery into the consuming vehicle.

- 7.2 Marking. When any grade designations in accordance with 5.3 are used on a blending pump the following shall apply.
 - (a) Each such designation shall be clearly associated with the particular bland or blends to which it refers.
 - (b) The petrol supplied to the consuming vehicle in association with such designation shall comply in all respects with the requirements of this British Standard for the grade in question.
 - (c) The provisions of 6.1 shall apply, except that the minimum diameter (point to point) of each star displayed on the pump may be reduced to 15 mm.
 - (d) In the case of additional stars indicating the setting of the selecter control for delivery of a particular blend, the minimum diameter (point to point) of each such additional star may be reduced to 10 mm, provided that stars complying with the requirements in (b) and (c) above are displayed on the pump.

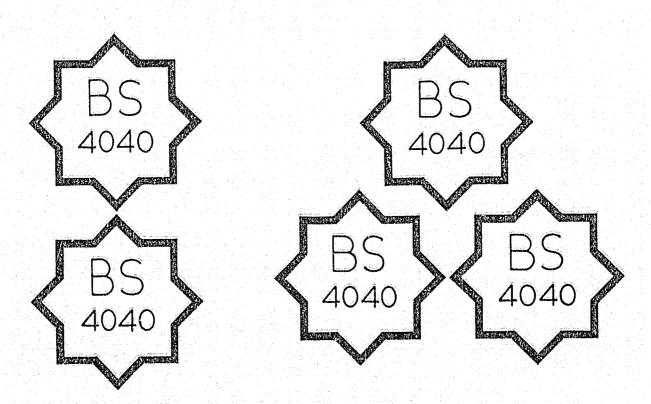


Figure 1. Grade designations for petrols [2 star and 3 star]

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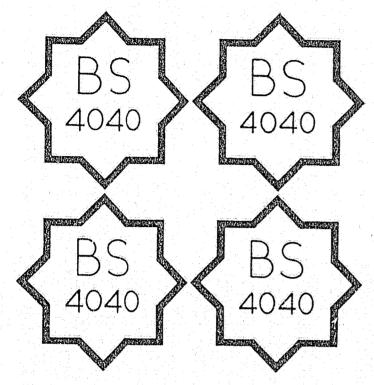


Figure 2. Grade designations for petrols (4 star)

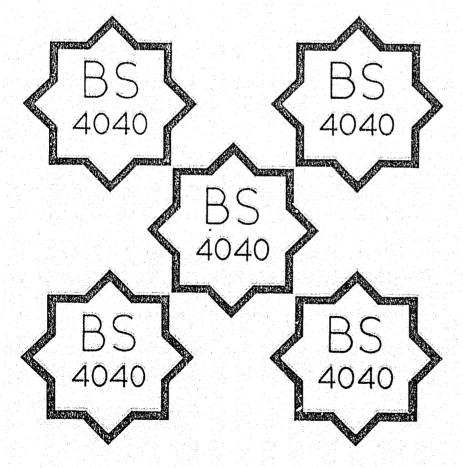


Figure 3. Grade designations for petrols (5 star)

Standard publications referred to

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BS 2637	Motor and aviation type fuels - Determination of knock characteristics - Motor method (ISO 5163)	444
BS 2638	Motor and aviation type fuels - Determination of knock characteristics - Research method (130 5104)	
BS 3195	Methods for sampling petroleum products	
77, 77, 7	Park 1 I tay 1d by decembrane - Manual sampling [ISO 3170]	
BS 4306	Becommendations for the application of precision data to specifications for petroleum products	
BS 4347	Method for determination of exidation stability of gasoline (induction period method)	
BS 4348	Method for determination of existent gum in fuels by jet evaporation (EN 5)	
BS 4349*	The same of the authorities the section for the model tiple	
BS 4350	Method for the determination of sulphur in petroleum products and liquefied petroleum (LP) gases tramp me	athod)
BS 4351*	figure to the self-residual tention of analysis appropriate but portroloum products.	
BS 5657	Petroleum products - Gasoline - Determination of lead content - Iodine monochloride method [ISO 3830]	I

This British Standt	ard, having been prepared u	Inder the direction of	grade designations, Enquiries should be addressed to the
the Petroleum Star authority of the Ex	ndards Committee, was pub xecutive Board on 29 Septe	olished under the ember 1978 and is	Publications Manager, 101 Pentonville Road, London N1 9 (Telephone 01-837 8801; Telex 23218).
© British Standard	ebruary 1979 (see foreword Is Institution, 1978	14.	Contract requirements Attention is drawn to the fact that this British Standard d
First published Ma			purport to include all the necessary provisions of a contract
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ISBN 0 580 10408	3.7 andards are reminded that	n and the section of	of amendment slips or of revised editions, it is important users of British Standards should iscertain that they are in possession of the latest amendments or editions.
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PETROL (GASOLINE) FOR MOTOR VEHICLES Part 1 LEADED PETROL

AS 1876, Part 1-1982

PUBLISHED BY THE STANDARDS ASSOCIATION OF AUSTRALIA STANDARDS HOUSE, 80 ARTHUR ST, NORTH SYDNEY, N.S.W.

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PREFACE

This standard was prepared by the Association's Committee on Petrol for Motor Vehicles under the direction of the Consumer Standards Advisory Committee. This edition now constitutes Part 1 of the standard for petrol and as such supersedes AS 1876—1976, Petrol for Motor Vehicles. This standard not only takes account of the various grades of leaded petrol that are currently available to the consumer, but also specifically refers to 'leaded' petrol, since it has been proposed that 'unleaded' petrol should become available in 1985. As a consequence the standard for unleaded petrol, which is in the course of preparation, will form Part 2 of AS 1876.

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Australian Standard

for

PETROL (GASOLINE) FOR MOTOR VEHICLES

PART 1—LEADED PETROL

FOREWORD

This standard, which constitutes Part 1 of the standard for petrol, relates to leaded petrol.

Although this standard specifies requirements for some of the more important properties of leaded petrol (also known as gasoline or motor spirit), it should be noted that it does not deal with all the essential properties necessary to ensure a quality product. Notably, properties such as distillation range and vapour pressure have been omitted because of the wide range of climatic conditions encountered across Australia and the necessity of varying these properties according to season and location. Essentially then, this standard is concerned with the performance of leaded petrol in terms of its anti-knock value.

In addition, the standard provides a colour coding system for the three commonly available grades of leaded petrol, as well as requiring that the RON (Research Octane Number) of each grade of leaded petrol be displayed on the dispensing pump or any container of leaded petrol intended for public sale.

The requirement for the addition of an identifying agent to petrol has not been specified as the committee believes that this is unnecessary for the following reasons:

- (a) The cost differential between 97 octane and 89 octane fuel is now so small as to make the deliberate adulteration of 97 octane fuel unattractive.
- (b) In practice it has been exceedingly difficult to obtain and use a suitable identifying
- (c) Tests can be readily carried out in any laboratory certified by NATA to carry out octane determinations if doubts arise concerning the Research Octane Number of a particular sample of leaded petrol.

The committee considered the possibility of including a more convenient, but not necessarily cheaper, method of determining octane values; however, suitable alternative methods were not available.

Although the tests specified in this standard can be readily carried out, it is stressed that where the laboratory tests are being performed, it is essential that the equipment and procedures are exactly as laid down in the appropriate test method. In particular, for the determination of the Research Octane Number it is essential that a properly inspected and maintained standard CFR (Coordinating Fuel Research Committee) engine be used. The satisfactory operation and test precision of CFR engines in Australia is ensured by the engine test correlation program of the National Association of Testing Authorities (NATA).

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SPECIFICATION

1 SCOPE. This standard specifies requirements for three grades of leaded petrol.

NOTE: In Australia, the most common term for motor fuel is 'petrol'. Alternative terms are 'gasoline' and 'motor spirit',

2 APPLICATION. This standard applies to leaded petrol for use in motor vehicles powered by spark-ignition internal-combustion engines.

This standard does not apply to aviation petrols (AVGAS),

REFERENCED DOCUMENTS. The following documents are referred to in this standard:

BS 3195 Methods for Sampling Petroleum Products Part I-Liquid Hydrocarbons: Manual Sampling

BS 4306 Recommendations for the Application of Precision Data to Specifications for Petroleum Products

Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test (BS 4351 is technically ident-ASTM D 130-IP 154

ASTM D 270 Method of Sampling Petrol-cum and Petroleum Products

Test Method for Existent Gum in Fuels by Jet Evapor-ation (BS 4348 is technically ASTM D 381-IP 131 identical)

Test Method for Oxidation Stability of Gasoline (Induc-tion Period Method) (BS 4347 ASTM D 525-IP 40 is technically identical)

ASTM D 1266-IP 107 Test Method for Sulfur In Petroleum Products (Lamp Method) (BS 4350 is technically identical)

ASTM D 2699—IP 237 Test Method for Knock Characteristics of Motor Fuels by the Research Method

ASTM D 3341 or IP 270 Test Method for Lead in Gasoline—Iodine Mono-chloride Method

4 DEFINITIONS. For the purpose of this standard, the following definitions apply:

Additives—chemical substances added to petrol usually in small quantities, to impart desirable properties to, or prevent deterioration of, the petrol.

Extenders—oxygenates that may be added to petrol as part of a petrol conservation scheme.

5 COMPOSITION. Leaded petrol shall consist essentially of volatile hydrocarbons and shall not include water or suspended matter which is visible to a person with normal vision.

Leaded petrol may contain additives and/or extenders.

6 REQUIREMENTS.

6.1 General. All grades of leaded petrol shall have properties that comply with the limits specified in Table 1, when tested in accordance with the methods indicated therein.

In the event of dispute as to the appropriate value of any of the properties listed in Table 1, the relevant procedures specified in BS 4306 shall be used to interpret the laboratory results,

NOTE: Appendix A describes the relevant methods to be used to obtain a representative sample of leaded petrol.

- 6.2 Nominal Research Octane Numbers. When determined in accordance with ASTM D 2699—1P 237, the grade, i.e. the anti-knock value, expressed as the nominal Research Octane Number (RON), of leaded petrol shall be one of the following:
 - (a) 89;
 - (b) 92; or
 - (c) 97.

In the event of dispute as to the appropriate RON value, the relevant procedures specified in BS 4306 shall be used to interpret the laboratory results.

Appendix A describes the relevant methods to be used to obtain a representative sample of leaded petrol.

obtain a representative sample of leaded petrol.

2. Where the RON value from a single determination is less than the nominal (i.e. marked or claimed) RON value, then the method of Appendix B is to be used to decide, with 95 percent confidence, whether the true RON value of the leaded petrol is less than its claimed or marked RON value. For the definition of true RON value, see the Note to Paragraph B1 of Appendix B.

- 6.3 Colour Coding. Each grade of leaded petrol shall be coloured as specified in Table 2, to a hue and depth which is similar to the corresponding reference colour solution specified in Appendix C.
- 7 MARKING. The following information shall be marked on each dispensing pump and each container of leaded petrol intended for sale to the public:
- (a) The brand name or trademark of the leaded petrol.
- (b) The nominal RON value of the leaded petrol.

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AS 1876, Part 1-1982

Property	Limit	Test method				
Copper corrosion—3 h at 50°C Sulphur content—% by mass Existent gum—mg/100 ml. Oxidation, stability—min. Lead content—g/L at 15°C	Class I maximum 0.2 maximum 4 maximum 240 minimum As permitted by Government legislation	ASTM D 130—IP 154 ASTM D 1266—IP 107 ASTM D 381—IP 131 ASTM D 525—IP 40 ASTM D 3341 or IP 270				

TABLE 2 COLOUR OF THE VARIOUS GRADES OF LEADED PETROL

Nominal	RON value	Colour
	89	Yellow Purple
	92 97	Red

- NOTES:

 1. Great precision in colour matching is not required as the colour has no effect on the performance of the petrol. The petrol is coloured simply to aid identification by the consumer.

 2. It is anticipated that from time to time the above colour coding system will require amendment as different grades of leaded petrol become available or existing grades are withdrawn.

 3. The term 'hue', as used in Clause 6.3, refers to the colour whereas the term 'depth' refers to the colour intensity.

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APPENDIX A SAMPLING

A1 SCOPE. This Appendix sets out methods for obtaining a representative sample of petrol for analysis.

A2 APPARATUS.

A2.1 Apparatus for Obtaining a Sample from Other Than a Petrol Pump. The apparatus for obtaining a representative sample from a fixed tank, railear, road vehicle, ship, barge, drum, can or from petrol that is pumped through a pipeline, shall be in proceedings with the relative of BS 2105. be in accordance with the relevant sections of BS 3195, Part 1.

NOTE: BS 3195, Part 1 is technically identical with the corresponding methods in IP 51 published by the Institute of Petroleum, and ASTM D 270 published by the American Society for Testing and Materials.

- A2.2 Apparatus for Obtaining a Sample from a Petrol Pump. The apparatus for obtaining a representative sample from a petrol pump shall be as follows:
 - (a) A stock of cans which are kept solely for the purpose of obtaining petrol samples. The cans shall be of 5 L and 1 L capacity which comply with the appropriate safety requirements for cans intended to hold highly flammable material. Each can shall have a petroleum-resistant scaling washer positioned in its cap,
 - (b) A clean, dry, metal funnel.

NOTE: A metal funnel has been specified in Paragraph A2.2(b) because some plastics funnels are prone to static charge which could cause an explosion when taking a sample of petrol.

A3 PROCEDURE.

- A3.1 Procedure for Obtaining a Sample from Other Than a Petrol Pump. The procedure for obtaining a representative sample from a fixed tank, railear, road vehicle, ship, barge, drum, can or from petrol that is pumped through a pipeline, shall be in accordance with the relevant sections of BS 3195, Part 1.
- A3.2 Procedure for Obfaining a Sample from a Petrol Pump. Where practicable, ensure that the sampling procedure is not carried out in direct sunlight. The procedure shall be as follows:
 - (a) Before using any can for sampling, the can shall be checked to ensure that it is sound and free from leaks. Further, just before the sample is taken, each new can shall be rinsed with a small quantity of the petrol to be sampled, to remove any residual oil left during the manufacture of the can.
 - (b) Using the clean, dry, metal funnel, carefully draw 5 L of petrol into a cool 5 L can from the petrol pump. Where it is desirable to have more than a 5 L sample, the above operation should be repeated immediately and before the pump has been used for any other purpose,
 - (c) Immediately after drawing the petrol from the pump, using the funnel, decant the 5 L sample or samples into the requisite number of 1 L cans, ensuring that the cans are filled approximately 15 mm from the brim.
 - (d) Tighten the screw caps fully and check to ensure that there are no leaks,
 - (e) If the cans have to be stored before the sample is analysed, ensure that they are stored in a cool, well ventilated place. Do not refrigerate. NOTES:
 - Where practicable, the sample and storage of the sample should not be in direct sunlight because not only is there an increased possibility of losing the volatile components of the sample, but also the hazard of fire or explosion is increased.
 Although a 1 L can of sample is sufficient for the determination of the RON and certain other tests, it is advisable to provide each laboratory with two 1 L cans of sample in ease further work is needed.

APPENDIX B

INTERPRETATION OF SINGLE RON DETERMINATION

B1 SCOPE. This Appendix sets out a statistical method for deciding, from a single RON determination, with 95 percent confidence, whether the true RON value of a sample of leaded petrol is less than its nominal (i.e. marked or claimed) RON value. NOTES:

The true RON value is the mean RON value of an infinite number of tests carried out on a representative sample taken from the leaded petrol which is being examined.
 If it is desired to establish the true RON value with greater precision, a greater number of RON determinations would be necessary and the results are to be assessed in accordance with BS 4306.

APPLICATION. This statistical procedure applies only where the single determined RON value of the sample is less than the nominal (i.e. marked or claimed) RON

B3 PRINCIPLE. Where the single determined RON value is less than the nominal (i.e. marked or claimed) RON value, a statistical relationship is used to ascertain, with 95 percent confidence, whether the true RON value, which remains unknown, of the leaded petrol is less than its nominal RON value.

B4 SAMPLING. A representative sample of the petrol shall be obtained in accordance with Appendix A.

NOTE: If it is desired to established the true RON value with greater precision, the number of samples would have to be substantially increased.

B5 PROCEDURE. The procedure shall be as follows:

- (a) Using the test method described in ASTM D 2699—1P 237, determine the RON value of the representative sample of petrol.
- (b) Then, using the result of the single RON determination, calculate whether-

$$X < A - \frac{0.84R}{\sqrt{2}}$$

which may be rounded off to-

$$X < A - 0.6R$$

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X =the RON value of the sample as determined in accordance with ASTM D 2699—IP 237

A = the nominal (i.e. marked or claimed) RON value of the sample

R = the reproducibility relative to the nominal RON value (see Table B1).

TABLE BI STATISTICAL DATA FOR CURRENT GRADE OF LEADED PETROL

Nominal RON	Reproducibility	0.84/2	A 0.84/8
value A 89	<i>R</i> ₹ 0.74	√2 0.4	√2' 88.6
92 97	0.74 0.66 0.64	0,4 0,4 0,4	91.6 96.6

1. Reproducibility, as referred to above, is u quantitative expression of the random error associated with operators working in different laboratories, each obtaining single results on u portion of the same sample. It is defined as that difference between two such single and independent results which would be exceeded in the long run in only one case in twenty in the normal and correct operation of the test method. (This is known as the 95 percent probability level.)

2. Extensive data from consumer and producer laboratories over a number of years for many samples of conventional petrols have shown that the reproducibility of fuel ratings between laboratories varies with octane number level. The reproducibility of the test method as specified in Table B1, has been calculated from information contained in ASTM D 2699—IP 237.

B6 INTERFRETATION From the calculation specified in Paragraph B5 (b), if-

$$X < A - \frac{0.84R}{\sqrt{2}}$$

then it may be assumed, with 95 percent confidence, that the true RON value is less than the nominal RON value.

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APPENDIX C

COLOURANTS FOR LEADED PETROL

- C1 SCOPE. This Appendix describes coloured reference solutions which are to be used for comparison with the appropriate grade of leaded petrol in terms of its hue, i.e. colour, and depth, i.e. colour intensity.
- C2 PRINCIPLE. For ease of identification, each grade of leaded petrol is coloured using any suitable dyestuff to a hue and depth that is similar to the hue and depth of the appropriate coloured reference solution.

C3 COLOURED REFERENCE SOLUTIONS.

C3.1 Yellow. The yellow reference solution shall be a homogeneous solution comprising 1.8 mg of a commercial yellow dye, which is essentially diethylamino azobenzene, per litre of primary reference fuel grade *iso*-octane.

- 1. Suitable commercial yellow dyes are -Williams Yellow DEA; or Waxoline Yellow EDS.
- Clause 6.3 requires that leaded petrol, having a nominal RON value of 89, should have a similar hue and depth to that of the yellow reference solution.
- C3.2 Purple. The purple reference solution shall be a homogeneous solution comprising 6 mg of a commercial purple dye, which is essentially 40 percent by volume of an anthraquinone dye, per litre of primary reference fuel grade iso-octane.

NOTES:

- 1. A suitable commercial purple dye is -Mortons Automate Purple RS.
- Clause 6.3 requires that leaded petrol, having a nominal RON value of 92, should have a similar hue
 and depth to that of the purple reference solution.
- C3.3 Red. The red reference solution shall be a homogeneous solution comprising 3 mg of a commercial red dye, which is essentially 70 percent by volume of an alkyl derivative of azobenzene-4-azo-2-naphthol, per litre of primary reference fuel grade iso-octane.

NOTES:

- 1. A sultable commercial red dye is -
- Mortons Oil Red B Liquid.

 2. Clause 6.3 requires that leaded petrol, having a nominal RON value of 97, should have a similar hue and depth to that of the red reference solution.

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Australian Standard 1876.2—1984

PETROL (GASOLINE) FOR MOTOR VEHICLES Part 2—Unleaded Petrol



STANDARDS ASSOCIATION OF AUSTRALIA
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This Australian standard was prepared by Committee CS/15, Petrol for Motor Vehicles. It was approved on behalf of the Council of the Standards Association of Australia on 14 August 1984 and published on 5 October 1984.

The following interests are represented on Committee CS/15:

Australian Automobile Association

Australian Federation of Consumer Organizations

Australian Institute of Petroleum Limited

Automotive and Petroleum Technical Council of Australia

Department of Defence

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Department of Resources and Energy

Department of the Territories and Local Government

Department of Transport

Environment Protection Authority of Victoria

Federal Chamber of Automotive Industries

Institution of Mechanical Engineers

National Association of Testing Authorities, Australia

Royal Australian Chemical Institute

Society of Automotive Engineers—Australasia

State Pollution Control Commission, N.S.W.

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PETROL (GASOLINE) FOR MOTOR VEHICLES Part 2 UNLEADED PETROL

AS 1876.2-1984

First published1984

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PREFACE

This standard was prepared by the Association's Committee on Petrol for Motor Vehicles under the direction of the Consumer Standards Advisory Committee. This standard is Part 2 of AS 1876 and relates to unleaded petrol which is to be available, throughout Australia, by 1 July 1985.

The other part of this standard is as follows:

AS 1876 Petrol (Gasoline) for Motor Vehicles
Part 1—Leaded Petrol

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AS 1876.2-1984

STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard

for

PETROL (GASOLINE) FOR MOTOR VEHICLES

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PART 2—UNLEADED PETROL

FOREWORD

This standard, which constitutes Part 2 of the standard for petrol, relates to unleaded petrol. Leaded petrol is specified in AS 1876, Part 1.

Although this standard specifies requirements for some of the more important properties of unleaded petrol (also known as gasoline or motor spirit), it should be noted that it does not deal with all the essential properties necessary to ensure a quality product. Notably, properties such as distillation range and vapour pressure have been omitted because of the wide range of climatic conditions encountered across Australia and the necessity of varying these properties according to season and location. Essentially then, this standard is concerned with the performance of unleaded petrol in terms of its anti-knock value.

In terms of its anti-knock value.

This standard requires that unleaded petrol be coloured. Green, colourless and yellow were considered; however since green is currently used for AVGAS, green was considered inappropriate because both petrol and AVGAS may be stored together (e.g., in rural areas) which could lead to disastrous results if for instance, unleaded petrol was used in a light aircraft. Colourless was also rejected because depending on the nature of the crude used to produce the unleaded petrol, it is possible that the product would naturally be coloured yellow and as such would not comply with the colourless requirement. Further, as it is intended that leaded petrol with a nominal Research Octane Number (RON) value of 89, which is currently coloured yellow, be phased out at the same time as unleaded petrol is introduced, it was believed that yellow should be retained for the unleaded petrol.

As will be observed from Table 1, the standard requires that the sulphur content of the

be retained for the unleaded petrol.

As will be observed from Table 1, the standard requires that the sulphur content of the unleaded petrol not exceed 0.10 percent (by mass). Although it is currently possible to produce unleaded petrol with sulphur concentrations below this maximum, it is recognized that occasionally there will be insufficient low sulphur crude available to produce such petrol. Accordingly, in order to maintain the supply of unleaded petrol, crudes of higher sulphur concentrations will need to be used more extensively, resulting in a petrol with a sulphur concentration that exceeds the maximum specified in Table 1. Under such conditions the petrol producer will need to obtain permission from the relevant Regulatory Authority to release such petrol for sale to the public. In this regard, it is generally accepted that, provided that the need to use crudes of high sulphur concentrations is not excessive, the Regulatory Authorities may temporarily extend the maximum concentration of sulphur in unleaded petrol to 0.15 percent (by mass).

(by mass).
In reference to the antiknock requirements, since the MON (Motor Octane Number) represents relatively severe conditions of engine operation while the RON (Research Octane Number) represents relatively mild conditions of engine operation, it is generally believed that the average of the MON and RON values, which is expressed as the Antiknock Index (AKI), most closely correlates with typical road performance of an engine, because under normal use, the engine of a motor vehicle operates under various degrees of severity. Because of this, in some countries (e.g. the USA and Canada) the antiknock requirements are expressed in terms of a minimum MON and minimum AKI only. However, for Australia, although a minimum AKI of 86.5 was considered appropriate, in order to maintain consistency with the requirements of the Regulatory Authorities (e.g. NSW Clean Air Act), it was decided that the antiknock requirements should be limited to the expression of the MON and RON values only, for at least this edition of the standard.

With respect to the test procedures, although the tests specified in this standard can

With respect to the test procedures, although the tests specified in this standard can be readily carried out, it is stressed that where the laboratory tests are being performed, it is essential that the equipment and procedures are exactly as laid down in the appropriate test method. In particular, for the determination of the MON and the RON it is essential that the appropriate Coordinating Fuel Research Committee (CFR) engines that are used are properly inspected and maintained. The satisfactory operation and test precision of CFR engines in Australia is ensured by the engine test correlation program of the National Association of Testing Authorities (NATA).

SPECIFICATION

for unleaded petrol. NOTE: In Australia, the	andard specifies requirements most common term for motor fuel is as are 'gasoline' and 'motor spirit'.
unleaded petrol for us spark-ignition internal This standard does N	This standard applies to a in motor vehicles powered by combustion engines. OT apply to aviation petrols
(AVGAS).	OCUMENTS. The following
documents are referred BS 3195	d to in this standard; Methods for Sampling Petrol-
	eum Products Part I—Liquid Hydrocarbons: Manual Sampling
BS 4306	Method for Determination and Application of Precision Data in Relation to Methods of Test for Petroleum Products
ASTM D 130-IP 154	Method for Detection of Copper Corrosion from
	Petroleum Products by the Copper Strip Tarnish Test (BS 4351 is technically identical)
ASTM D 381-IP 131	Test Method for Existent Gum in Fuels by Jet Evapora- tion (BS 4348 is technically identical)
ASTM D 525-1P 40	Test Method for Oxidation Stability of Gasoline (Induc- tion Period Method) (BS 4347 is technically identical)
ASTM D 1266-1P 107	Test Method for Sulfur in Petroleum Products (Lamp Method) (BS 2000: Part 107 is technically identical)
ASTM D 2622	Sulfur in Petroleum Products (X-ray Spectrographic Method)
	Test Method for Knock Characteristics of Motor Fuels by the Research Method
ASTM D 2700-IP 236	Test Method for Knock Characteristics of Motor and Aviation Fuels by the Motor Method
ASTM D 2785	Test Method for Trace Quantities of Total Sulfur (Wickbold and Beckman Combustion Apparatus)
ASTM D 3116	Test Method for Trace Amounts of Lead in Gasoline
ASTM D 3231	Test Method for Phosphorus in Gasoline
ASTM D 3237	Test Method for Lead in Gasoline by Atomic Absorp- tion Spectrometry
ASTM D 4057	Manual Sampling of Petrol- eum and Petroleum Products

ASTM D 4177	Automatic Sampling of Petroleum and Petroleum Products
IP 51	Sampling Petroleum and Products—Liquids, Semi-Solids and Solids
1P 336	Sulphur in Petroleum Pro- ducts by Energy-Dispersive X-ray Fluorescence (Non- Dispersive X-ray Fluores-

- 4 DEFINITIONS. For the purpose of this standard, the following definitions apply:
- 4.1 Additive—chemical substances added to petrol usually in small quantities, to impart desirable properties to, or prevent deterioration of, the petrol.
- 4.2 Extenders—oxygenates that may be added to petrol as part of a petrol conservation scheme.
- 5 COMPOSITION. Unleaded petrol-
- (a) shall consist essentially of volatile hydrocarbons;
- (b) shall not contain any phosphorus or compounds of phosphorus which have been added to the petrol;
- (e) shall not contain any water or suspended matter which is visible, without any aids, to a person with normal vision; and
- (d) may contain additives and/or extenders.

- I. As may be observed from Table 1, a maximum concentration for phosphorus is specified. However, the requirement of Clause 5(b) is intended to indicate that although naturally occurring phosphorus and its compounds are acceptable (up to the limit specified in Table 1), deliberate additions of such chemicals are not acceptable in unleaded petrol.
- Although Clause 5(d) permits the use of additives and/or extenders in unleaded petrol, the toxic nature of such compounds should be taken into consideration. Where additives and/or extenders are used, the concentration of these compounds should be such that they are not more injurious to health than the volatile hydrocarbons specified in Clause 5(a).

6 REQUIREMENTS.

6.1 General. Unleaded petrol shall have properties that conform to the limits specified in Table 1, when tested by the methods indicated therein.

In the event of dispute as to the appropriate value of any of the properties listed in Table 1, the relevant procedures specified in BS 4306 shall be used to interpret the laboratory results.

NOTE: Appendix A describes the relevant procedures to be used to obtain a representative sample of unleaded petrol.

6.2 Antiknock requirements. The antiknock properties for unleaded petrol shall conform to the limits specified in Table 2, when tested by the methods indicated therein.

In the event of a dispute as to the appropriate octane number, the relevant procedures specified in BS 4306 shall be used to interpret the laboratory results.

NOTES:

- See the comments about antiknock requirements in the Foreword.
- Appendix A describes the relevant procedures to be used to obtain a representative sample of unleaded petrol.

6.3 Colour coding. Unleaded petrol shall be coloured yellow to a depth (i.e. colour intensity) that is similar to a homogeneous solution comprising 4.5 mg of a commercial yellow dye, which is an alkylated di-azo dye, plus 0.6 mg of a commercial red dye, which is essentially 70 percent by volume of an alkyl derivative of azobenzene-4-azo-2-naphthol, per litre of a solvent consisting of 70 percent Primary Reference Fuel Grade n-heptane and 30 percent Reagent Grade toluene.

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- 1. See the comments about colour in the Foreword.
- 2. A suitable commercial yellow dye is Morton's Automate Yellow 8,

A suitable commercial red dye is Morton's Automate Red B.

- Red dye in the colour reference solution is necessary in order to allow realistic colour matching with commercial fuels which often contain natural red coloration in blending components.
- 7 MARKING. The following information shall be marked on each dispensing pump and each container of unleaded petrol intended for sale to the public:
- (a) The brand name or trademark of the unleaded petrol.
- (b) The words 'UNLEADED PETROL'.

NOTE: Manufacturers who place the number of this Australian standard on petrol dispensing pumps and containers, on packag-ing or on literature related to unleaded petrol should ensure that the product is manufactured to comply with this standard.

GENERAL REQUIREMENTS FOR UNLEADED PETROL FOR MOTOR VEHICLES

Property	Limit	Test method			
Lead content-	13 maximum	ASTM D 3116 or ASTM D 3237			
mg/L at 15°C Phosphorus content—	f.3 maxlmum	ASTM D 3237			
mg/L	0.10 maximum	ASTM D 1266-IP 107			
Sulphur content— % by mass	(see Foreword)	ASTM D 2785 ASTM D 2622 or			
A or or vesilion	Class I maximum	IP 336 ASTM D 130-1P 154			
Copper corrosion— 3 h at 50°C	Class I maximum				
Existent gum-mg/L	40 maximum	ASTM D 381-IP 131 ASTM D 525-IP 40			
Oxidation, stability—	240 minimum	ASIM D 323-11' 40			

TABLE 2 ANTIKNOCK REQUIREMENTS

	Property	Llmlt	Test method
	Motor octane number (MON)	82 minimum	ASTM D 2700-1P 236
. ;	Research octane number (RON)	91 minimum 93 maximum	ASTM D 2699-1P 237

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A1 SCOPE. This Appendix sets out procedures for obtaining a representative sample of petrol for analysis.

A2 APPARATUS.

A2.1 Apparatus for obtaining a sample from other than a petrol pump. The apparatus for obtaining a representative sample from a fixed tank, railcar, road vehicle, ship, barge, drum, can or from petrol that is pumped through a pipeline, shall be in accordance with the relevant sections of BS 3195, Part 1.

NOTE: BS 3195, Part 1 is technically identical with the corresponding methods in ASTM D 4057 and ASTM D 4177 published by the American Society for Testing and Materials and IP 51 published by the institute of Petroleum.

- A2.2 Apparatus for obtaining a sample from a petrol pump. The apparatus for obtaining a representative sample from a petrol pump shall be as follows:
- A stock of cans which are kept solely for the purpose of obtaining petrol samples. The cans shall be of 5 L and 1 L capacity which comply with the appropriate safety requirements for cans intended to hold highly sammable material. Each can shall have a petroleum-resistant sealing washer positioned in its cap.
- (b) A clean, dry, metal funnel.

NOTE: A metal funnel has been specif. An Paragraph A2.2(b) because some plastics funnels are prone to static charge which could cause an second when taking a sample of petrol.

A3.1 Procedure for obtaining a sample from other than a petrol pump. The procedure for obtaining a representative sample from a fixed tank, railear, road vehicle, ship, barge, drum, can or from petrol that is pumped through a pipeline, shall be in accordance with the relevant sections of BS 3195, Part I.

NOTE: See Note in Paragraph A2.1.

- A3.2 Procedure for obtaining a sample from a petrol pump. Where practicable, ensure that the sampling procedure is not carried out in direct sunlight. The procedure shall be as follows:
- (a) Before using any can for sampling, the can shall be checked to ensure that it is sound and free from leaks. Further, just before the sample is taken, each new can shall be rinsed with a small quantity of the petrol to be sampled, to remove any residual oil left during its manufacture.
- (b) Using the clean, dry, metal funnel, carefully draw 5 L of petrol into a cool 5 L can from the petrol pump. Where it is desirable to have more than a 5 L sample, the above operation should be repeated immediately and before the pump has been used for any other purpose.
- Immediately after drawing the petrol from the pump, using the funnel, decant the 5 L sample or samples into the requisite number of 1 L cans, ensuring that the cans are filled approximately 25 mm from the brim.
- (d) Tighten the screw caps fully and check to ensure that there are no leaks.
- (e) If the cans have to be stored before the sample is analysed, ensure that they are stored in a cool, well-ventilated place. Do not refrigerate.
 - Where practicable, sampling and storage of the sample should not be in direct sunlight because not
 only is there an increased possibility of losing the volatile components of the sample, but also the
 hazard of fire or explosion is increased.
 - Although two 1 L cans of sample are sufficient for the determination of octane numbers and certain other tests, it is advisable to provide each laboratory with four 1 L cans of sample in ease repeated testing is needed. If octane numbers are not required, one 1 L can of sample is adequate for the tests in Table 1.

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Standard Specification for LIQUEFIED PETROLEUM (LP) GASES1

This standard is issued under the fixed designation D 1835; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last revision. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1.1 This specification covers those products commonly referred to as liquefied petro-

leum gases.
1.2 This specification is applicable to products intended for use as domestic, commercial, industrial, and engine fuels,

1.3 This specification is for use in formulating specifications for required properties of liquefied petroleum gases at the time of delivery in bulk.

1. Applicable Documents

2.1 ASTM Standards:

D1265 Method of Sampling Liquefied Petroleum (LP) Gases?

D1267 Test Melliod for Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method)2

D1657 Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer²

D1837 Test Method for Volatility of Liquefied Petroleum (LP) Gases³ D1838 Test Method for Copper Strip Corre-

sion by Liquefied Petroleum (LP) Gases1

D2158 Test Method for Residues in Liquefied Petroleum (LP) Gases³

D2163 Method of Analysis of Liquefied Petro-leum (LP) Gases and Propene Concentrates by Gas Chromatography

1)2420 Test Method for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acelate Method)3

D2598 Method for Calculation of Certain Physical Properties of Liquelied Petroleum (LP) Gases from Compositional Analysis³

13713 Test Method for Dryness of Propane (Valve Freeze Method)

132784 Test Method for Sulfur in Liquefied

Petroleum Gases (Oxy-Hydrogen Burner or Lamp)1

2.2 Other Documents: GPA Publication 21404

3. Types

3.1 Four basic types of liquefied petroleum gases are provided to cover the common use applications, as follows:

3.1.1 Commercial Propane - A hydrocarbon product for use where high volatility is required,

3.1.2 Commerical Butane - A hydrocarbon product for use where low volatility is required.

3.1.3 Commercial PB Mixtures - Mixtures of propane and butane for use where interme-

diate volatility is required.
3.1.4 Special-Duty Propane -- A high-quality product composed chiefly of propane, which exhibits superior antiknock characteristics when used as an internal combustion engine fuel.

4. Detall Requirements

4.1 The four types of liquefied petroleum gases shall conform to the requirements prescribed in Table 1.

5. Sampling

5.1 Proper sampling of liquefied petroleum gases is extremely important if the tests are to be significant. All samples shall be obtained in accordance with Method D 1265.

¹ This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.
Current edition approved Aug. 27, 1982. Published January 1983. Originally published as D 1835 = 61 T. Lass previous edition D 1835 = 76 (1981).

² Annual Book of ASTM Standards, Vol 05.01

³ Annual Book of ASTM Standards, Vol 05.07.

⁴ Available from Gas Processors Assn., 1812 First Place, T. Okla, 74103.

- Company of the second	<u> </u>	Pr	oduct Designati	on:	
	Commercial Propane	Commercial Butane	Commercial PB Mixtures	Special-Duty Propane	ASTM Test Methods (see Section 2)
Vapor pressure at 100°F (37.8°C), max. psig	208 1430	70 485	II.	208 1430	D 1267 or D 2598'
Volatile residue: evaporated temperature, 95 %, max, °F °C	-37 -38.3	16 2.2	36 2,2	-37 -38.3	D 1837
or butane and heavier, max, vol % pentane and heavier, max, vol % Propylene content, max, vol %	2.5	2.0	20	2.5 5.0	D 2163 D 2163 D 2163
Residual matter: residue on evaporation 100 ml, max, ml oil stain observation	0.05 pass"	0.05 pass**	0.05 pass ¹¹	0.05 pass ⁿ	D 2158 D 2158 D 1657 or
Relative density (specific gravity) at 60/ 60°F (15.6/15.6°C)			No. I	No. I	D 2598 D 1838
Corrosion, copper, strip, max Sulfur, grains/100 h ¹ max at 60°P and 14.92 psia mg/m ¹ (15.6°C and 101 kPa)	No. 1 2 - 15 343	No. 1 15 343	15 343	10 229	D 2784
Hydrogen sulfide content Moisture content Free water content	pass	none"	none	pass ^P pass	D 2420 D 2713

A Equivalent to Propane HD-5 of GPA Publication 2140.

**The permissible vapor pressures of products classified as PB mixtures must not exceed 200 psig (1380 kPa) and additionally must not exceed that calculated from the following relationship between the observed vapor pressure and the observed specific gravity:

Vapor pressure, max = 1167 - 1880 (sp gr 60/60°F) or 1167 - 1880 (density at 15°C)

Vapor pressure, max = 1167 - 1880 (sp gr 60/60°F) or 1167 - 1880 (density at 15°C)

A specific mixture shall be designated by the vapor pressure at 100°F in pounds per square inch gage. To comply with the designation, the vapor pressure of the mixture shall be within ±0 to ±10 pst of the vapor pressure specified.

In case of dispute about the vapor pressure of a product, the value actually determined by test method D 1267 shall prevail over the value calculated by D 2598.

An acceptable product shall not yield a persistent oil ring when 0.3 ml of solvent residue mixture is added to a filter paper, in 0.1-ml increments and examined in daylight after 2 min as described in Method D 2158.

Although not a specific requirement, the specific gravity must be determined for other purposes and should be reported Additionally, the specific gravity of PB mixture is needed to establish the permissible maximum vapor pressure (see Footnote b).

h).

Additionally, the specific gravity of PB mixture is needed to establish the permission interpretable product thalf not show a distinct coloration.

An acceptable product thalf not show a distinct coloration.

The presence of absence of water shall be determined by visual inspection of the samples on which the gravity is determined.

APPENDIX

XI. SIGNIFICANCE OF ASTM SPECIFICATIONS FOR LIQUEFIED PETROLEUM (LP) GASES

XI.1 General

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X1.1.1 Liquefied petroleum gas products are composed of those readily liquefiable hydrocarbon compounds which are produced in the course of processing natural gas and also in the course of the conventional refining of crude oil. The composition of liquefied gases can vary widely depending upon the source and the nature of the treatment to which the products have been subjected.

X1.1.2 There are many uses for liquefied petroleum gases. Important uses are, (1) as domestic, commercial, and industrial fuels, (2) as a carbon source material in metal treating operations, (3) as refinery raw materials for synthetic gasoline pro-

duction, and (d) as petrochemical raw materials. The nature of the needs dictates the required composition characteristics in these various applications. Since the last three uses of those listed are in the category of specialty applications which involve special requirements, they are excluded from consideration in the specifications.

X1.1.3 in substance, the ASTM Specifications for Liquefied Petroleum Gases are designed to properly define acceptable products for domestic commercial, and industrial uses. In many cases it will be fire d that products meeting the specifications with also be usable in applications other than the ones for which they were designed. The following may be accepted as a general guide in the more

common use applications of the three types of fuels:

X1.1.3.1 Commercial Propane—This fuel type is the one preferred for domestic, commercial, and industrial use, particularly in geographical areas and in seasons where low ambient temperatures are common, and where uniformity of fuel is an important consideration.

X1.1.3.2 Commercial PB Mixtures—This fuel type, since it covers a broad range of mixtures, permits the tailoring of fuels to specific needs. The various mixtures find application as domestic, commercial, and industrial fuel in areas and at times when low ambient temperature conditions are less frequently encountered.

X1.1.3.3 Commercial Butane—This fuel type finds limited application as a domestic fuel in areas of warmer climates. It is similarly used in industrial applications where problems of fuel vaporization are not present.

applications where problems of fuel vaporization are not present.

X1.1.3.4 Special-Duty Propane—This fuel type is a special liquefied petroleum gas product tailored to meet the restrictive needs of internal combustion engines operating under moderate to high engine severity. Fuel products of this type will be less variable in composition and combustion characteristics than the other products covered by this specification.

X1.2 Significance

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X1.2 Significance

X1.2.1 Since commercial liquefied petroleum gases are essentially either single component products, depending upon fuel type, it follows that all of the important behavior characteristics of such products can be defined and controlled by a relatively few simple measurements. The specification tests which are provided achieve the desired result. The significance of the various tests as they may apply to consumer problems is summarized here.

X1.2.1.1 Vapor Pressure, Volatility, and Gravity:

to consumer problems is summarized here. X1.2.1.1 Vapor Pressure, Volatility, and Gravity:

X1.2.1.1 Vapor Pressure is an indirect measure of the most extreme low-temperature conditions under which initial vaporization can be expected to take place. It can be considered as a semiquantitative measure of the amount of the most volatile material present in the product. If may also be used as a means for predicting the maximum pressures which may be experienced at fuel task temperatures. Vapor pressure becomes more significant when it is related to volatility. X1.2.1.1.2 Volatility, expressed in terms of the 95 % evaporated temperature of the product, is a measure of the amount of least volatile fuel component present in the product. Coupled with a vapor pressure limit, it serves to assure essentially single-component products in the cases of commercial propane and commercial butane fuel types. When volatility is coupled with a vapor pressure limit which has been related to gravity, as in the case of the commercial PB-mixture type of fuels, the combination serves to assure essentially two component mixtures for such fuels. When coupled with a proper vapor pressure limit, this measurement

serves to assure that special-duty propane products will be composed chiefly of propane and propylene and that propane will be the major constituent.

X1.2.1.1.3 Gravity. by itself, has little significance. It becomes of value only when related to vapor pressure and volatility. Since gravity is of importance in meeting transportation and storage requirements it is always determined for all lique-fied petroleum gas products.

X1.2.1.2 Other Product Characteristics—While the vaporization and combustion characteristics of commercial liquefied gas products are completely defined for the normal use applications by vapor pressure. volatility, and gravity, as given in X1.2.1.1, there are other items which either affect or might affect the results obtained in some specific use applications. For that reason, limits are specified for residue content, copper corrosion, sulfur content, moisture content, and free water content to provide assurance of product dependability under the more extreme conditions of use.

X1.2.1.2.1 Residue (End Point Index) is a measure of the concentration of combustible hydrocarbon materials present in the product which are substantially less volatile than the liquefied petroleum gas hydrocarbons. Control over residue content is of considerable importance in use applications where the fuel is used in liquid feed systems. In such cases, failure to limit the permissible concentration of residue materials may result in troublesome deposits, it is also of importance where the fuel vapors are withdrawn from the top of the storage container. In such applications, regulating equipment tends to become fouled up if excessive amounts of residue are present in the field.

X1.2.1.2.2 Capper Corroston limits are for the purpose of providing assurance that difficulties will not be experienced in the deterioration of the top-per and copper-alloy fittings and connections which are commonly used in many types of utilization, storage, and transportation equipment. The further provision that special-duty propane p

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X1.2.1.2.5 Free Water Content is of importance only on the commercial PB-mixtures and commercial butane type products. These two types of products are normally used under ambient conditions

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which are mild and, as a consequence, the only requirement is vigilance to assure that no free v_k ter is present.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five year and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for addition, standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you show, make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.



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Specification for

Commercial butane and propane

Butane et propane commerciaux Handelsübliches Butan und Propan

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Foreword

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This British Standard was first published in 1968, under the authority of the Petroleum Industry Standards Committee, in response to a request by the Ministry of Defence for a specification covering commercial butane and commercial propane. This revision, superseding BS 4250: 1968, was initiated when it was found that difficulties were being experienced by producers in meeting the requirements for hydrogen sulphide content; a new method of test has been introduced that can be carried out more quickly and is better suited to the hydrogen sulphide concentrations found in practice. Since publication of the 1968 edition a method for the determination of total sulphur using the Wickbold combustion apparatus has been published in BS 3156 'Methods of analysis for fuel gases' Part 5 'Techniques for high pressure gases', and a method for mercaptan sulphur has been published in BS 4386 'Determination of mercaptan sulphur content of light hydrocarbon products (silver nitrate method)' identical with the method published by the Institute of Petroleum as IP 104/53, which was specified in the previous edition. A method for sampling petroleum gases has not yet been published as a British Standard and pending the publication of a British Standard reference should be made to the latest edition of IP 181 'Sampling petroleum gases, including liquefied petroleum gases'. Details of the methods for the determination of hydrogen sulphide, of volatility and of odour are given in appendices A, B and C respectively.

A method for the determination of oil residues in bulk supplies of liquefied petroleum (LP) gases has been developed by the American Society for Testing and Materials (ASTM) and published as Method D 2158-65 'Test for residues in liquefied petroleum (LP) gases'. For guidance, it is suggested that bulk supplies of commercial butane and propane should meet the following limits when tested by this method:

R Number (residue number) 10 max.

O Number (oil number) 33 max.

Limits have not been included in this British Standard as part of the general requirements because the acceptable values can vary with the application and should be agreed between the purchaser and the supplier.

To overcome the effects of the small amount of dissolved water in propane it is the practice to dry commercial propane or to add up to one part of methanol to 800 parts of liquid propane by volume, so as to inhibit ice and hydrate formation. A method for checking for ice and hydrate formation in propane has been published by the ASTM as Method D 2713-70 'Test for dryness of propane (valve freeze method)'. It has not been considered necessary to include this test in this British Standard but it may be specified by agreement between the purchaser and the supplier.

For general guidance, details of certain physical properties of low-boiling hydrocarbons and related compounds have been included in appendix D, but the values stated do not form part of the specification. In this edition the tables have been revised to take account of recently published information and to give the data in units consistent with the International System of units (SI). Test gases to cover the combustion characteristics of commercial butane and propane (3rd family gases) are described in BS 4947 'Test gases for gas appliances'.

British Standard Specification for

Commercial butane and propane

1. Scope

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This British Standard specifies requirements for the quality of commercial butane and commercial propane suitable for general domestic and industrial fuel purposes. These gases may be supplied in cylinders or in bulk.

Different limits may be required for certain purposes and, in such cases, the limits or any supplementary requirements should be agreed between the purchaser and the supplier.

2. References

The titles of British Standards referred to in this standard are listed on the inside back cover.

3. General requirements

3.1 Sampling. All samples shall be taken in liquid phase in accordance with the appropriate method described in

3.2 Total sulphur. The total sulphur content (after stenching) shall not exceed 0.02 % (m/m), as determined by the method described in 3.4.2 of BS 3156 : Part 5 : 1969+.

The method described in 3,4,2 of BS 3156: Part 5: 1969 expresses the sulphur content of the gas in micrograms per cubic metre but for the purposes of this British Standard the sulphur content shall be calculated as a percentage

(a) Gravimetric finish

Sulphur content of gas, % $(m/m) = \frac{13.74 \times m_2}{m_4}$

 m_1 is the mass of gas burnt (g); m_2 is the mass of barium sulphate (g).

(b) Nephelometric finish

Sulphur content of gas, % $(m/m) = \frac{8.016 \times 10^{-3} \times P}{m_t}$

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m, is the mass of gas burnt (g);

 u^{\prime} is the volume of 0.0025M barium chloride solution used (ml).

3.3 Hydrogen sulphide. The hydrogen sulphide content shall be not greater than 0.5 p.p.m. (V/V) (0.75 mg/m³ of gas volume) when determined by the method described in appendix A. This limit ensures that the concentration of hydrogen sulphide in any part of a distribution system is no greater than 2.5 p.p.m. (MN) based on a distribution factor between liquid and gas of 5.

3.4 Acetylenes. The total content of acetylenes shall not exceed 2 moles per cent, as determined by gas chromatography

*Pending publication of BS, all sampling for the purposes of this British Standard is to be carried out in accordance with the relevant sections of the current edition of IP 181 'Sampling petroleum gases, including liqueffed petroleum gases'.

A European Standard (EN 41), 'Determination of the sulphur content of petroleum gases, including inqueried petroleum gases. A European Standard (EN 41), 'Determination of the sulphur content of petroleum products by the Wickbold combustion method', is in course of preparation and, when it is published as a British Standard, an amendment to this standard will be published so that EN 41 will supersede BS 3156: Part 5 for the purposes of this requirement; IP 243/70 T 'Sulphur in petroleum products, Wickbold oxy-hydrogen method' is technically equivalent.

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3.5 Containers and markings. The containers in which the commercial butane or propane is supplied shall comply with the appropriate regulations or specifications relating to materials, construction and marking. The requirements for non-refillable containers are described in BS 3690: Part 1 and refillable containers in BS 5045: Part 2*.

It is strongly recommended that each consignment of commercial butane or propane complying with the requirements of this British Standard should be identified as such by the use of the British Standard number, i.e. BS 4250, on, for instance, one or more of the following.

- (a) The original order, quotation or similar document relating to the consignment.
- (b) An advice note or similar document accompanying the consignment.
- (c) The cylinder or other container in which the material is supplied, or a label attached thereto.
- 3.6 Filling ratios. The maximum filling ratios for the containers in which commercial butane or propane is supplied shall comply with the requirements of BS 1736⁴.

4. Requirements specific to commercial butane

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- 4.1 Description. Commercial butane shall be a hydrocarbon mixture consisting predominantly of butanes and/or butylenes. It shall not contain harmful quantities of toxic or nauseating substances and shall be free from mechanically-entrained water.
- 4.2 Mercaptan sulphur. The content of mercaptan sulphur (after stenching) shall not exceed 0.004 % (m/m), as determined by method A described in BS 43861.
- 4.3 Volatility, 95 % (1/V) of the material shall evaporate at a temperature of 2.2 °C (36 °F) or below; this temperature is referred to a reference barometric pressure of 1013.25 mbar§ (760 mmHg), when tested by the procedure described in appendix B.
- 4.4 Vapour pressure. The vapour pressure at 45 °C shall be not greater than a gauge pressure of 5.86 barl when determined by the method described in BS 3324 °C.

Additionally, for the portable container trade only, the vapour pressure at 45 °C shall be not less than a gauge pressure of 4.85 bur when determined by the method described in BS 3324 °C.

- 4.5 Dienes. The total content of dienes shall not exceed 10 moles per cent, as determined by gas chromatography or mass spectrometry.
- 4.6 Odour. The odour of the gas shall be distinctive, unpleasant and non-persistent, and shall indicate the presence of gas down to concentrations in air of 20 % of the lower limit of flammability when tested by the method described in appendix C. The lower limit of flammability for commercial butane may be taken as 1.9 % (1/1/1) in air.

5. Requirements specific to commercial propane

- 5.1 Description. Commercial propose shall be a hydrocarbon mixture consisting predominantly of propose and/or propylene. It shall not contain harmful quantities of toxic or nauscating substances and shall be free from mechanically-entrained water (see foreword, third paragraph).
- 5.2 Mercaptan sulphur. The content of mercaptan sulphur (after stenching) shall not exceed 0.005 % (m/m), as determined by method A described in BS 4380‡.
- 5.3 C_2 hydrocarbons. The total content of C_2 hydrocarbons shall not exceed 5.0 moles per cent, as determined by gas chromatography, mass spectrometry or infra-red spectrometry.
- 5.4 Ethylene. The total content of ethylene shall not exceed 1.0 moles per cent, as determined by gas chromatography, mass spectrometry or infra-red spectrometry.

^{*} This British Standard specification for pas cylinders appropriate for use with commercial butane and propane is based on the Report of the Home Office Gas Cylinders and Containers Committee; a further Part is in the course of preparation.

[†] In course of revision on the basis of the Report of the Home Office Gas Cylinders and Confainers Committee.

[#] BS 4386 is technically identical with IP 104.

^{§ 1} mbar = 10° N/m2 = 0.1 kPa.

^{1 1} bar = $10^5 \text{ N/m}^3 = 100 \text{ kPa}$.

EBS 3324: 1961 is technically identical with IF 161/59 Tea European Standard is in course of preparation that will be technically equivalent to IF 161/73 and will be published as a revision of BS 3324.

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5.5 C_4 and higher hydrocarbons. The total content of C_4 and higher hydrocarbons shall not exceed 10 moles per cent, as determined by gas chromatography, mass spectrometry or infra-red spectrometry.

NOTE. Guidance on methods for the determination using gas chromatography may be obtained from BS 3156: Part 4 and ASTM D 2163-70:IP 264/72 'Analysis of liquified petroleum (LP) gases and propylene concentrates by gas chromatography'.

5.6 C_5 and higher hydrocarbons. The total content of C_5 and higher hydrocarbons shall not exceed 2 moles per cent, as determined by gas chromatography or mass spectrometry (see note and foreword, second paragraph).

NOTE. This requirement ensures an adequate volatility for commercial propane and no separate requirement for volatility has been specified. If desired the method described in Appendix B may be used and limits agreed between the purchaser and the supplier.

5.7 Vapour pressure. The vapour pressure at 45 °C shall be not greater than a gauge pressure of 17.6 bar* when determined by the method described in BS 3324†.

5.8 Odour. The odour of the gas shall be distinctive, unpleasant and non-persistent, and shall indicate the presence of gas down to concentrations in air of 20 % of the lower limit of flammability when tested by the method described in appendix C. The lower limit of flammability for commercial propane may be taken as 2.4% (V/V) in air,

* 1 bar = 10 * N/m = 100 kPa.

[†] BS 3324: 1961 is technically identical with IP 161/59 T; a European Standard is in course of preparation that will be technically equivalent to IP 161/73 and will be published as a revision of BS 3324.

Appendix A

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Method for determination of hydrogen sulphide in liquefied petroleum (LP) gases

- A.1 Introduction. This appendix describes a method for the determination of hydrogen sulphide in LP gases. The concentrations determined are in the range 0.5 p.p.m. (V/V) to 4 p.p.m. (V/V) (0.75 mg/m³ to 6 mg/m³).
- A.2 Summary of method. The method is based on that described in 'Methods for the defection of toxic substances in air', Booklet No. 1, 'Hydrogen sulphide', published by HMSO, 1969. A measured volume of vaporized gas is passed through a prepared paper and the stain obtained is compared with standard strins.
- A.3 Apparatus. The stainless steel used for the apparatus shall be a suitable austenitic stainless steel. The following apparatus is required.
- A.3.1 200 ml stainless steel bomb (see notes 1 and 2).
- A.3.2 Stainless steel pressure coupling*.
- A.3.3 Water bath maintained at 40 °C.
- A.3.4 Tubes and valves, sampling lines, a coil of $2 \text{ m} \times 3 \text{ mm}$ o.d. tube, a 3-way stopcock and a needle valve for flow control in stainless steel.
- A.3.5 Test paper holder as shown in figure 1.
- A.3.6 Water manometer.
- A.3.7 Wet gas meter preferably passing 0.25 litre of gas per revolution.
- A.3.8 Reference staints (see note 3).
- NOTI 1. It is recommended that, where possible, this test should be carried out on LP gas drawn, as liquid, direct from the container rather than collected in a bomb; this procedure avoids errors that may arise from the tendency of stainless steel to absorb hy drogen sulphide.
- NOTE 2. The bomb described in IP Standards for Petroleum and its Products Part IV, Methods for Sampling IP 181/62, is suitable.
- NOTE 3. A suitable set of reference stains is provided in 'Methods for the detection of toxic substances in air', Booklet No. 1, 'Hydrogen sulphide', published by Her Majesty's Stationery Office, 1969. These stains are produced for use with 125 ml of test sample and when used in connection with the present procedure should be interpreted as equivalent to 0.5, 1, 2 and 4 p.p.m. (IVI) (0.75, 1.5, 3 and 6 mg/m³).

 It should be noted that these stains should be protected from exposure to light when not being used.
- A.4 Reagents. Lead acetate test papers are required and should be prepared from reagents of recognized analytical quality and water complying with the requirements of BS 3978, as follows.

Dissolve 10 g of lead acetate, (CII, COO), Pb.3II, O, in 90 ml of water. Add 5 ml of acetic acid, glacial (17 mol/1), and 10 ml of glycerol to the solution and mix well. Prepare this solution freshly for each batch of test papers.

Immerse strips of chromatographic paper; 20 mm wide and about 100 mm long, vertically in this solution, contained in a 100 ml measuring cylinder, for 1 min. Withdraw the strips from the liquid, allow the excess liquid to drain off, suspend them vertically and allow them to dry as completely as possible at room temperature in an atmosphere free from 11, S. When dry, cut off and discard the top and bottom 25 mm of the treated strips to leave the test napers (see note).

Store the test papers in a stoppered, wide necked, dark bottle to protect them from air and light. Use the test papers within 14 days of preparation.

NOTE. There should be no stain visible on a test paper before use. It has been found that some lead acetate papers purel used in bulk may be satisfactory if cut to sire (20 mm × 50 mm) and damped with a line spray of water.

A.5 Procedure. Assemble the apparatus as shown in figure 2 (but see note 1 of A.3) with the coil and needle valve immersed in the water bath at 40 °C. Fit the test paper centrally between the gaskets of the test paper holder and serew the holder finger tight. Close the needle valve tightly and open the lower valve on the sample bomb. Take the reading on the wet gas meter and open the needle valve and adjust it to give a flow rate of vaporized gas of 125 ml/mln.

When the wet gas meter indicates that 1250 ml of gas has passed through the system, turn the 3-way stopcock to the vent position and close the lower valve on the sample bomb. Remove the test paper from the holder and immediately compare the stain on it with the reference stains (see note 3 of A.3).

^{*}A map fitting of the Octiker of Schraeder type is suitable.

^{*}Whatmin No. 3 MM is suitable.

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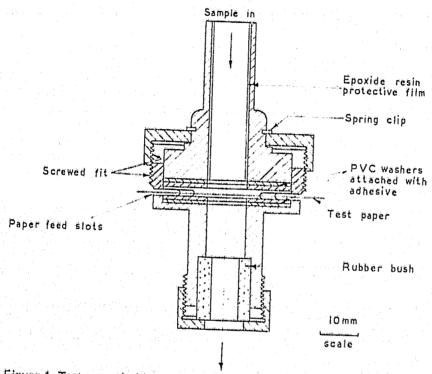


Figure 1. Test paper holder

Reproduced from 'Methods for the detection of toxic substances in air' Booklet No. 1 'Hydrogen sulphide' by kind permission of HM Factory Inspectorate.

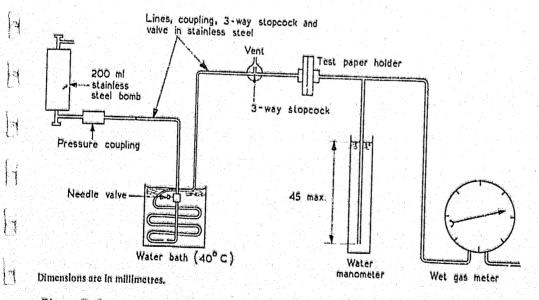


Figure 2. Apparatus for determination of hydrogen sulphide in LP gases

If the test paper is stained on both sides, indicating that the hydrogen sulphide has not been fully absorbed by the paper, prepare fresh test papers and repeat the test. Should both sides of the fresh test paper be stained the test should be repeated using a reduced volume of gas to give an approximate indication of the concentration of hydrogen sulphide present.

Appendix B

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Method of test for volatility of liquefied petroleum (LP) gases (Based on ASTM Method D1837-64*)

B.1 Introduction. This appendix describes a method for the approximate determination of the amount of higher boiling constituents present in the various types of LP gases. The test results, when properly related to the observed vapour pressures and densities of LP gases, may be used to indicate the approximate concentration of butane in the propane-type LP gases, and of pentanes in the propane-butane mixtures and butane-type LP gases. The presence of hydrocarbons less volatile than those of which the LP gas is primarily composed is indicated by the temperature of the 95 % (V/V) evaporated point.

B.2 Summary of method. The LP gas is refrigerated by means of a cooling coil and 100 ml of the liquid is collected in a weathering tube. The liquid is allowed to weather under specified conditions and the temperature is observed when 95% (V/V) has evaporated. Correction is made for deviations of barometric pressure from the reference value of 1013.25 mbart (760 mmHg).

B.3 Apparatus. The following apparatus is required

B.3.1 Weathering tube. This shall be a centrifuge tube, cone-shaped, conforming to the dimensions given in figure 3 and made of thoroughly annealed heat-resistant glass. The shape of the lower tip of the tube is especially important. The taper shall be aniform and the bottom shall be rounded as shown in figure 3. The graduation tolerances are given in table 1.

B.3.2 Tube support. Means shall be provided for supporting the weathering tube by its neck in a vertical position.

B.3.3 Water bath. (Only required for tests on butane and propane-butane mixtures.) This shall be a shallow container filled with clean water having the temperature maintained between 15 °C and 20 °C and a depth of 40 mm.

Table 1. Weathering tube graduation tolerances

Range	Scale division	Limit of error	
ml	ınl	ml	
0.0 to 0.1	0.05	+0.02	
0.1 to 0.3	0.05	±0.03	
0.3 to 0.5	0.05	+0.05	
0.5 to 1.0	0.1	±0,05	
1.0 to 2.0	0.1	10.10	
2.0 to 3.0	0.2	±0.10	
3.0 to 5.0	0.5	±0.20	
5.0 to 10.0	1.0	±0.50	
10.0 to 25.0	5.0	±1.0	
25.0 to 100.0	25.0	±1.0	

^{*} Reproduced with amendments from the American Society for Testing and Materials Book of Standards 1973, Part 18, whose courtesy is hereby acknowledged; the amendments provide for the metrication of the method and are based on the corresponding document approved by Working Group 19, Methods of test for petroleum products, of the European Committee for Standardization (CIN).

^{† 1} mbar = 10° N/m² = 0.1 kPa.

[#] Horosilicate glass has been found satisfactory for his purpose.

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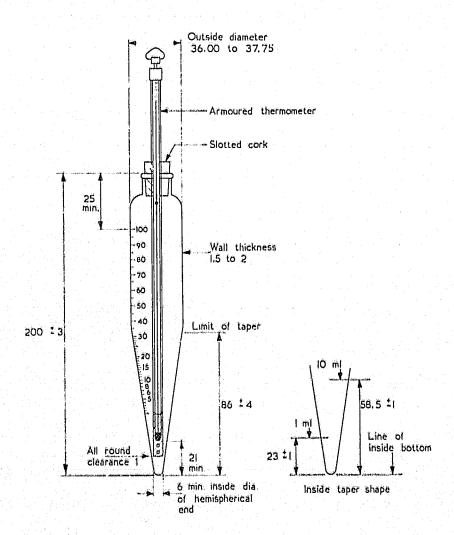
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Dimensions are in millimetres.

NOTE. For graduation tolerances, see table 1.

Figure 3. Weathering tube

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B.3.4 Thermometer. ASTM armoured weathering test thermometer having a range of $-55\,^{\circ}$ F to $+40\,^{\circ}$ F ($-48\,^{\circ}$ C to $+4.5\,^{\circ}$ C) and complying with the requirements given in B.7 shall be used. Until suitable thermometers calibrated in Celsius degrees are available the corresponding Fahrenheit thermometer may be used.

B.3.5 Sample precooling equipment

B.3.5.1 Cooling vessel. Any suitable wide-mouthed glass or metal container, or Dewar flask of at least 65 mm inside diameter and 290 mm deep, may be used.

B.3.5.2 Cooling coil. Approximately 6 m of 6 mm outside diameters of the copper tubing (see BS 2871: Part 2) is required, wound around a hollow mandrel of at least 53 mm outside diameter, with adjacent turns touching. Run the lower end of the tube up through the centre of the mandrel before winding so that the finished coil will fit snugly inside the cooling vessel. When assembled, the top of the coil shall be at least 25 mm below the top of the vessel and the open ends of the coil shall be not more than 100 mm above it. Connect the downstream end of the coil to a needle valve having an outlet connection not more than 75 mm long (see figure 4).

B.3.5.3 Precoolant. The precoolant may be LP gas from the same container from which the sample is to be taken but special care should be taken to avoid possible ignition of the vapour. For increased safety a non-flammable precoolant may be used, which should be a refrigerant having a boiling point lower than the initial boiling point of the sample.

B.4 Procedure

B.4.1 Calibration of tube for 5 % (1/1/1) residue level. Before carrying out the test introduce the armoured thermometer as far into the centrifuge tube as it will go but at the bottom leave a 1 mm clearance between the armour and the tube wall; position the bottom of the thermometer bulb at least 21 mm from the bottom of the inside of the tube. Pipette 5 ml of water into the tube and observe the water level. The 5 % (1/1/1) residue readings are to be taken at this same level with the armoured thermometer in the same position as during this calibration. Empty and dry the tube before proceeding with the test.

B.4.2 Obtaining a test portion. Fill the cooling vessel with the precoolant so as to cover the cooling coil. Attach the inlet of the cooling coil to the source from which the test portion is to be taken with a short connecting pipe of 6 mm outside diameter or larger, having a draw-off valve large enough to prevent vaporization of the material due to the drop in pressure across the valve seat. Purge the line and cooling coil by opening both the draw-off valve and the needle valve on the downstream end of the cooling coil. Fill the weathering tube with the liquid flowing through the cooling coil. Empty this first portion, then add one or two grains of charcoal and refill the weathering tube to the 100 ml mark with fresh liquid from the cooling coil. Carefully insert the precooled armoured thermometer into the centrifuge tube in the same position as in B.4.1. Centre the armoured thermometer in the tube by means of a slotted cork. Do not remove the armour from the thermometer during the test.

B.4.3 Weathering butane and propane-butane mixtures. If the temperature of the test portion is below $12\,^{\circ}\text{C}$ allow it to weather in the atmosphere until the temperature has reached $12\,^{\circ}\text{C}$. Then place the weathering tube, with the armoured thermometer still in place, in the water bath in a vertical position, submerging it to the 1.5 ml mark and allow the contents to weather. When the liquid level reaches the graduation corresponding to 5%(V/V) residue as determined according to B.4.1, read the thermometer, maintaining its position in the weathering tube.

B.3.4 Weathering propane. Allow the test portion to weather in the atmosphere, taking care to disturb the frost on the tube as little as possible. An acctone or alcohol swab may be used to remove sufficient frost to permit reading of the temperature. When the liquid level reaches the graduation corresponding to 5% (V/V) residue as determined according to B.4.1, read the thermometer, maintaining its position in the weathering tube.

B.4.5 Determination of ice point. After making the final temperature reading, remove the armoured thermometer from the weathering tube and place it up to the immersion line in a bath of finely crushed ice. Record the reading of the thermometer when a constant reading is obtained. If the thermometer reading differs from 0.0 °C by ± 0.5 °C or less correct the final test reading by the corresponding amount. If the thermometer reading differs from 0.0 °C by more than ± 0.5 °C the thermometer should be discarded and the weathering test repeated (see note).

NOTE. A high reading of the thermometer at the ice point usually indicates that there is a break in the mercury-thalliam thread. This can be corrected by warming the thermometer gently in a warm water bath to drive the break upward into the expansion chamber, at the top of the thermometer. While an unbroken thread of mercury-thallium extends into the upper chamber, tap the bottom of the thermometer on a hard but cashioned surface to join the liquid into a continuous thread. A low reading at the ice point usually indicates that some of the liquid is remained in the expansion chamber. To correct this, allow the thermometer to warm so that the liquid enters the chamber and then tap the thermometer as previously instructed.

B.5 Interpretation of results

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B.5.1 Correct the thermometer reading at the 95 % (V/V) boiling point (5 % (V/V) residue) obtained in B.4.3 or B.4.4 for the error at the ice point as described in B.4.5 to give the corrected temperature.

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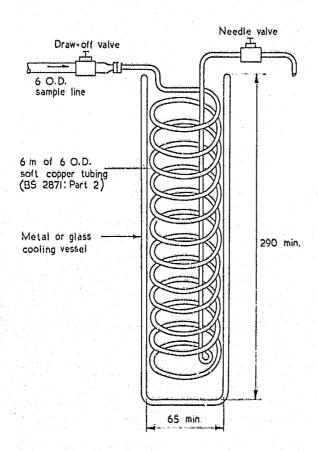
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Dimensions are in millimetres unless otherwise stated

NOTE. The colls in the drawing are extended for clarity.

Figure 4. Precooling equipment

B.5.2 Adjust the corrected temperature (from B.5.1) for the effect of the deviation in atmospheric pressure from the reference atmospheric pressure of 1013.25 mbar* (760 mmHg) as described in B.5.3. or B.5.4.

B.5.3 In the weathering test for propane, add 0.30 °C (0.55 °F) to the corrected temperature for each 13.33 mbar (10 mmHg) that the test is conducted below 1013.25 mbar, or subtract 0.30 °C (0.55 °F) from the corrected temperature for each 13.33 mbar that the test is conducted above 1013.25 mbar.

B.5.4 In the weathering test for butane and propane-butane mixtures, add 0.40 °C (0.7 °F) to the corrected temperature for each 13.33 mbar that the test is conducted below 1013.25 mbar, or subtract 0.40 °C (0.7 °F) from the corrected temperature for each 13.33 mbar that the test is conducted above 1013.25 mbar.

B.6 Precision. The precision of the method, as obtained by statistical examination of interlaboratory test results, is as follows.

(a) Repeatability. The difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

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(b) Reproducibility. The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

1.7 °F (1.0 °C) in weathering test for butane and propane-butane mixtures 2.3 °F (1.3 °C) in weathering test for propane

B.7 Specification for armoured test thermometer. The thermometer shall be suitable for assembly in a 310 mm non-sparking metal armour with open face.

Range -55 °F to +40 °F (-48 °C to +4 °C) (see note 1) Thermometric liquid A suitable mercury-thallium alloy Stem form Round or lens-front Immersion 35 mm (see note 2) Subdivisions 0.5 °F (0.2 °C) Long lines at each 1 °F (0.5 °C) 5 °F (2 °C) Numbered at each 0.4 °F (0.2 °C) Scale error, max. Expansion chamber Elongated type, to permit heating to 150 °F (66 °C) Total length 299 to 305 mm Stem diameter 6.5 to 8.0 mm Bulb length 15 to 20 mm Bulb diameter 6 to 7 mm Distance from bottom of bulb to line at -55 °F (-48 °C) 50 to 75 mm Distance from bottom of bulb to line at + 40 °F (+4 °C) 244 to 265 mm Glass button

The thermometer shall be calibrated for an average temperature of 10 °F (-25 °C) for the emergent mercury-thallium column.

NOTE 1. The only suitable type of thermometer available commercially is the ASIM Armoured Weathering Test Thermometer 991-641, which is calibrated in Fahrenfielt degrees; the equivalent values in Celsius degrees are given to encourage the production of equivalent Celsius thermometers.

NOTE 2. It is essential that the immersion line be visible in the case opening after assembly and that the immersion be measured from the bottom of the bulb.

^{*} I mbar = 102 N/m2 = 0.1 kPa.

Appendix C

Method of test for odour of liquefied petroleum (LP) gases*

C.1 Introduction. This appendix describes a method for assessing the odour of commercial LP gases which have either an odour due to the presence of unsaturated hydrocarbons or an odour imparted by the addition of odorants.

C.2 Outline of method. The LP gas is vaporized and diluted with purified air so that the mixture contains the gas at a concentration of 20 % of the lower limit of its flammability† in air. The odour of the gaseous mixture is assessed by at least three observers.

C.3 Apparatus. The apparatus is shown diagrammatically in figure 5 and consists of the following parts.

C,3.1 Air purifying column: a drying tower of approximately 200 ml capacity.

C.3.2 Flowmeter, such as one operating on the floating element principle, for air; range 5 1/min to 15 1/min.

C.3.3 Flowmeter, such as one operating on the floating element principle, for LP gas; range 5 ml/min to 150 ml/min.

C.3.4 Gas mixing bulb, 30 mm diameter with a jet 4 mm diameter.

C.3.5 Glass funnel, diameter 75 mm.

C.4 Material. Activated charcoal 1.18 mm to 1.70 mm (10 mesh to 14 mesh) for purifying the air stream.

C.5 Procedure. Pass air through the air purifier at the specified rate as measured by the air flowmeter. The air rate for propane shall be 8.5 l/min and that for butane shall be 10.5 l/min.

Place the nose inside the rim of the funnel and inhale gently; check that the air is odourless.

Then pass the stenched gas through the gas flowmeter at a rate of 40 ml/min. The odour of the LP gas-air mixture shall be assessed by at least three observers.

C.6 Reporting of results. If the odour is judged to be distinctive and unpleasant by all the observers, the batch, which the sample represents, shall be reported as complying with the requirements for odour.

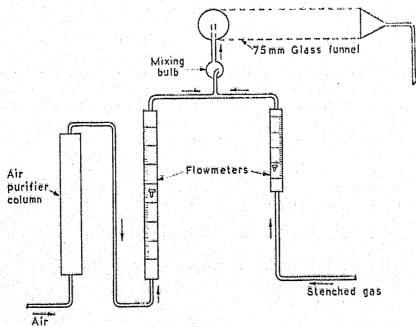


Figure 5. Apparatus for assessing ordour of LP gases

- * Alternatively, by agreement between the purchaser and the vendor, the method and apparatus described in the Gas Council's Research Communication GC 59, 'The odour and adortization of gas', may be used.
- † The lower limits of flammability in air for butane and propane may be taken as:

butane 1.9 % (1717) propane 2.4 % (1717)

Appendix D

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Physical properties of low-boiling hydrocarbons and related compounds

NOTE. The values in tables 2 and 3 have been mainly derived from the data in 'Calorific values and specific gravities; Calculation from composition' by J Wrobel and P Wright, British Gas Corporation, August 1973.

Table 2. Boiling points and densities

Gas	Relative molecular	Boiling	Compressibility	Density* at 15		
	mass	point at Lutm	15 °C,	Ideal gas	Real gas	
And the state of t	weight) (see note 1)	(see notes 2 and 3)	dry	Relative to air = 1	Relative to air = 1 (see note 5)	kg/m³
methane ethane propane butane isobutane pentane isopentane neopentane	16.043 30.070 44.097 58.124 58.124 72.151 72.151 72.151	-161.5 - 88.6 - 42.1 - 0.5 - 1!.7 - 36.1 - 27.9 - 9.5	0.9981 0.9915 0.9819 0.9659 0.9701 0.9435 0.9482 0.958	0.5537 1.0378 1.5219 2.0060 2.0060 2.4901 2.4901 2.4901	0.5548 1.0467 1.5500 2.0768 2.0678 2.6392 2.6261 2.5993	0.6798 1.2828 1.8994 2.5451 2.5340 3.2341 3.2184 3.1853
ethylene propene but-1-ene cisbut-2-ene transbut-2-ene isobutene	28,054 42,081 56,108 56,108 56,108	-103,7 - 47.7 - 6.3 - 3.7 - 0.9 - 6.9	0.9939 0.9838 0.9692 0.9651 0.9652 0.9685	0.9682 1.4523 1.9364 1.9364 1.9364 1.9364	0.9741 1.4762 1.9979 2.0064 2.0062 1.9994	1,1938 1,8090 2,4483 2,4590 2,4585 2,4503
buta-1,2-diene buta-1,3-diene	54.092 54.092	10.9 - 4.4	0.97 (sec 0.975 note 4)	1,8668 1,8668	1.9245 1.9147	2.3583 2.3463
earbon menoride earbon dioxide hydrogen nitrogen oxygen air	28.011 44.010 2.016 28.013 31.998 28.964	-191.5 - 78.5 -252.7 -195.8 -183.0 -194.3	0,9995 0,9943 1,0006 0,9997 0,9992 0,9996	0.9667 1.5188 0.0696 0.9668 1.1043 0.9996	0.9672 1.5275 0.0696 0.9671 1.1052 1.0000	1.1852 1.8718 0.0853 1.1851 1.3543 1.2254

The densities of the C₃ hydrocarbons given in this table are provided only for use in gas analysis calculations.
 1 atm = 1013.25 mbar = 101.325 kPa.

NOTE 1. Calculated from relative atomic masses conforming to $C_{12} = 12$.

NOTE 2. Values taken from API Project 44 Data Boiling Points of Hydrocarbons, Tables 1a (1952), 8a (1954), and 11a (1952). NOTE 3. HANNA, WS and MATTESON, R. Physical constants of low boiling hydrocarbons and miscellaneous compounds. Oil Gas J. 1947: 45(36), 51.

NOTE 4. Physical Constants of Hydrocarbons C, to C to ASTM Special Technical Publication No. 109A.

NOTE 5. Calculated from ideal gas densities using the compressibility factors.

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Table 3. Heats of combustion (gas phase)

Hydrocarbon	Heat of combustion at constant pressure relate to standard reference conditions of 15 °C, 1 atm*, dry							
	Gross			Net (see note 1)				
4. Company of the second secon	kJ/mol	MJ/kg	Ideal gas MJ/m²	Real gas MJ/m³	kJ/mol	MJ/kg	Ideal gas MJ/m³	Real gas MJ/m ³
methane ethane ptopane butane isobutane pentane isopentane neopentane	891.6	55.578	37.71	37.78	802.8	50.043	33.95	34.02
	1562.1	51.950	66.07	66.64	1428.9	47.520	60.43	60.95
	2221.1	50.368	93.94	95.67	2043.5	46.341	86.43	88.02
	2879.9	49.547	121.80	126.10	2657.9	45.728	112.41	116.38
	2871.4	49.401	121.44	125.18	2649.4	45.582	112.05	115.50
	3538.7	49.046	149.66	158.62	3272.3	45.354	138.39	146.68
	3531.4	48.944	149.36	157.52	3265.0	45.252	138.09	145.64
	3516.9	48.743	148.74	155.26	3250.5	45.051	137.47	143.50
othylene	1412.1	50.335	59.72	60.09	1323.3	47.170	55,96	56.31
propene	2059.2	48.934	87.09	88.52	1926.0	45.769	81,46	82.79
but-1-ene	2718.7	48.454	114.98	118.63	2541.1	45.289	107,47	110.88
cisbut-2-ene	2711.7	48.33	114.69	118.84	2534.1	45.165	107,18	111.06
transbut-2-ene	2708.5	48.273	114.55	118.68	2530.9	45.108	107,04	110.90
sobutene	2701.3	48.145	114.25	117.97	2523.7	44.980	106,74	110.21
outa-1,2-diene	2595,9	47.990	109.79	113.18	2462.7	45.528	104.16	107.37
outa-1,3-diene	2543,9	47.028	107.59	110.34	2410.7	44.566	101,96	104.56

^{* 1} atm = 1013.25 mbar = 101.325 kPa.

NOTE 1. Not heats of combustion have been calculated from the corresponding gross values using the latent heat of vaporization of water at 15°C = 44.4 kJ/mol.

NOTE 2. Typical mean Wobbe numbers for commercial butane and propage are as follows:

commercial butane 85.8 MJ/m3 (15 °C, 1 atm, dry), commercial propane 77.5 MJ/m3 (15 °C, 1 atm, dry).

Table 4. Vapour pressure of commercial propane and butane

Temperature	Maximum developed saturation vapour pressure (gauge), bar*				
*c	Commercial propane	Commercial butane			
42.5	16.8	5,51			
45	17.6	5,86			
47,5	18.7	6.27			
50	19,8	6.69			
52,5	20,9	7.03			
55	22,1	7,52			
57. \$	23.4	8.00			
60	24.6	8.55			
62.5	25.9	9.10			
65	27.3	9.58			
67.5	28.6	10,20			
70	30.0	10.89			

^{* 1} bar = 105 N/m2 = 100 kPai, I bar = 14.50 lbt/in3

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LIQUEFIED PETROLEUM GAS

SPECIFICATIONS AND TEST METHODS

REVISED (METRIC) EDITION
SEPTEMBER 11, 1973

AUSTRALIAN LIQUEFIED PETROLEUM GAS ASSOCIATION

NORWIGH HOUSE, & O'CONNELL STREET, SYDNEY, N.S.W.

MILSONS POINT, N.S.W. 2061

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PREFACE

These specifications are intended to apply to finished products for sale as domestic, commercial or industrial fuels.

They were prepared by the L.P. Gas Specification Committee of the Australian Liquefied Petroleum Gas Association, with the assistance of its Technical Sub-Committee. The latter advised on complex technical points, and carried out considerable laboratory investigation thereon.

The Specifications substantially follow those of the Natural Gas Processors Association in U.S.A. and the American Society for Testing and Materials, but have been modified to suit Australian conditions.

A guiding principle has been protection of the general public in terms of safety and quality.

It is recommended that Statutory Authorities who might use these Specifications as a guide for Regulations, should provide for exceptions where a supplier and a user might mutually desire variation therefrom for a specific use.

Where it is felt that explanations will be helpful, these are provided in the appended explanatory notes.

These Specifications and Test Methods were first issued on November 15, 1962. Subsequent revisions are dated February 21, 1964, February 3, 1970 and September 11, 1973 (first metric edition).

Issued 11/9/73

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AUSTRALIAN LIQUEFIED PETROLEUM GAS ASSOCIATION

SPECIFICATION COMMITTEE - TECHNICAL SUB-COMMITTEE

This Sub-Committee is convened from time to time to deal with specification and test method problems which may require laboratory investigation.

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Membership at its last assignment was published in the edition dated February 3, 1970.

DEFINITION OF LIQUEFIED PETROLEUM GAS

The term "Liquefied Petroleum Gas" shall mean a material which is composed predominantly of any of the following hydrocarbons or mixtures of all or any of them - propane (C_3H_8), propylene (C_3H_6), butanes (C_4H_{10}), or butylenes (C_4H_8).

II. SPECIFICATIONS FOR LIQUEFIED PETROLEUM GAS

All liquefied petroleum gas within the scope of these specifications shall conform with the following General Specification, and shall further conform with the Specification for Commercial Propane, Commercial Butane or Butane-Propane mixtures, whichever is applicable.

111. GENERAL SPECIFICATION

Residue on Complete Evaporation

The residue shall not be more than 2 milligrams per 100 millilitres as determined by the test described in Appendix 1 to this specification.

Volatile Sulphur

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The odourised gas, or if odourising is not required, then the unodourised gas, shall not contain volatile sulphur in excess of 0.34 grams per cubic metre at 15°C, 101.325 kilopascals and dry, as determined by ASTN Method D2784-70.

Corrosive Compounds

The product shall be free of corrosive compounds as determined by ASTM Method D1838-64.

Odour Level

The gas shall have an odour throughout its vapourisation from the liquid state, which is distinct, unpleasant and non-persistent, and of an intensity which indicates the presence of gas down to 1/5th of the lower flammability limit. The odour intensity shall be determined by using equipment of the type in which a stream of the gas is mixed with pure air, and the proportion of the gas to air is determined at threshold odour level. Odourisation shall not be required whenever it would be harmful in the further processing of

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the gas, or would interfere seriously with a specific industrial use. Any odourant added shall be a material proved in practice to be suitable for odourisation of liquefied petroleum gas. (Note - Appendix 2, Note 1.)

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The gas shall not contain any component in such concentration as to render it toxic to humans when used for any rational purpose.

IV: SPECIFICATION FOR COMMERCIAL PROPANE

Definition

Commercial Propane shall be a hydrocarbon product composed predominantly of propane and/or propylene as determined by ASTM Method D2163-70 or TP Method 264/72; and shall conform with the following specifications in addition to the General Specification laid down above.

Heating Value

The gross heating value of the vaporised product shall not be less than 48.8 megajoules per kilogram measured at 15°C and 101.325 kilopascals.

The method test shall be based on gas chromatography as specified by IP Method 264/72 and A.S.T.M. 2163:70. For calculation of heating value the heating values of the individual components shall be taken from Appendix 3. The values for individual components shall be multiplied with their respective volume fraction. The sum of the component heating values shall be divided by a factor of 1.0004 to give the heating value at 15°C, 101.325 kilopascals and dry to specification (Note 4 Appendix 2). To convert to heating value per unit weight, calculation shall be made from the analysis using the density values given in Appendix 3.

Vapour Prossure

The vapour pressure at 40°C as determined by ASTM Method D1267-67 or 1P Method 161-73 shall not exceed 1530 kilopascals gauge pressure:

Volatile Residue

The temperature at which 95% by volume of the product has evaporated Revised 11/9/73

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shall be - 38°C or lower when corrected to a barometric pressure of 760 millimetres of mercury, as determined by ASTM Method D1837-64.

Alternately the content of butane and heavier hydrocarbons shall not exceed 2.5% liquid volume as determined by ASTM Method D2163-70 or IP Method 264/72.

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The product shall be dry as determined by either of the N.G.P.A. Commercial Propose Dryness Tests as laid down in N.G.P.A. Publication 2140-70. Bither the Cobalt Bromide or the Dew Point method or both shall be used and if the product conforms with one of these tests it shall be considered dry.

V. SPECIFICATION FOR COMMERCIAL BUTANE

Definition

Commercial Butane shall be a hydrocarbon product composed predominantly of butanes and/or butylenes as determined by ASTM Method D2163-70 or IP Method 264/72 and shall conform with the following specifications in addition to the General Specification laid down above.

Heating Value

The gross heating value of the vaporised product shall not be less than 47.7 megajoules per kilogram measured at 15°C and 101.325 kilopascals.

The method of test shall be based on gas chromatography as specified by IP 264/72 or ASTM 2163-70. For calculation of heating value the heating values of the individual components shall be taken from Appendix 3. The values for individual components shall be multiplied with their respective volume fraction. The sum of the component heating values shall be divided by a factor of 1.0177 to give the heating value at 15°C, 101.325 kilopascals and saturated with water. To convert to heating value per unit weight, calculation shall be made from the analysis using the density values given in Appendix 3.

Vapour Pressure

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The vapour pressure at 40°C as determined by ASTM Method D2167-67 or IP Method 161/73 shall not exceed 520 kilopascals gauge pressure.

Volatile Residue

The temperature at which 95% by volume of the product has evaporated shall be 2°C or lower when corrected to a barometric pressure of 760 millimetres of mercury, as determined by ASTM Method D1837-64.

Alternately the content of pentane and heavier hydrocarbons shall not exceed 2.0% liquid volume as determined by ASTM Method D2163-70 or IP Method 264/72.

Dryness

The product shall not contain free entrained water as revealed by visual inspection.

VI. SPECIFICATION FOR BUTANE -PROPANE MIXTURES

Definition

Butane-Propane mixtures shall be hydrocarbon products composed predominantly of mixtures of butanes and/or butylenes with propane and/or propylene, as determined by ASTN Method D2163-70 or IF Method 26/72 and shall conform with the following specifications in addition to the General Specification laid down above.

Henting Value

The gross heating value of the vaporised product shall not be less than 47.7 megajoules per kilogram measured at 15°C and 101.325 kilopascals.

The method of test shall be based on gas chromatography as specified by IP 264/72 or ASTM 2163-70. For calculatio, of heating value the heating values of the individual components shall be taken from Appendix 3. The values for individual components shall be multiplied with their respective volume fraction. The sum of the component heating values shall be divided by a factor of 1.0177 to give the heating value at 15°C, 101.325 kilopascals and saturated with water.

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To convert to heating value per unit weight, calculation shall be made from the analysis using the density values given in Appendix 3.

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Butane-Propane mixtures shall be designated both as to their maximum and minimum vapour pressure at 40°C in kilopascals gauge pressure as determined by ASTM Method D1267-67 or IP Method 161/73; and it is also required that such maximum vapour pressure shall not exceed 1530 kilopascals gauge pressure.

Volatile Residue

The temperature ut which 95% by volume of the product has evaporated shall be 2° C or lower when corrected to a barometric pressure of 760 millimetres of morcury, as determined by ASTM Method D1837=64.

Alternately the content of pentane and heavier hydrocarbons shall not exceed 2.0% liquid volume as determined by ASTM Method D2163-70 or IP Method 264/72.

Dryness

If the vapour pressure at 40°C exceeds 1240 kilopascals gauge pressure the product shall be dry as determined by either of the N.G.P.A. Commercial Propane Dryness Tests as laid down in N.G.P.A. Publication 2140-70. Either the Cobalt Bromide or the Dew Point method or both shall be used and if the product conforms with one of these tests it shall be considered dry. If the vapour pressure at 40°C is equal to or less than 1240 kilopascals gauge pressure, the product shall be free of entrained water by visual inspection.

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APPENDIX 1

Method of Test for Residue in Liquefied Petroleum Gases on Complete Vaporisation

Scope

This method of test is intended for the determination of the residue when L.P. gas is evaporated to dryness.

Apparatus

- Evaporation Assembly The evaporation assembly shall be as shown in Figure 1, and shal contain the following items of equipment:
 - Contact Column: The contact column shall be of glass tubing 38 mm in diameter and 762 mm in length, filled % full with 6 mm (approx.) Raschig rings. It shall be connected to the flask and to the rest of the system by ground-glass joints.
 - Flask: The flask shall be a (b) 1-litre round-bottomed flask of heat-resisting glass.
 - Steam Coil: The steam coil shall be arranged to boil the contents (0) of the flask.
- Sample Container (2) The sample container hereafter referred to as the container shall be 3 litres approximate capacity meeting all the requirements of the Standards Association of Australia for steel cylinders for L.P. gas. Provision shall be made for opening and inspection of the inside of the container which shall be fitted with valves at both ends, a tube extending to the bottom and a dip leg to provide a minimum of 20 per cent outage.
- (3) Evaporating Dish The evaporating dish shall be an anticreeping beaker.

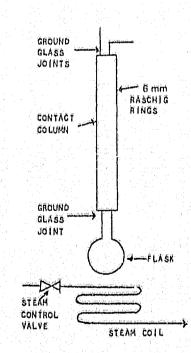


FIGURE 1

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APPENDIX 1

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The solvent shall be either chemically pure carbon tetrachloride or chemically pure chloroform.

Spot Samples

- (1) In all sampling and transferring operations it is <u>imperative</u> that extreme precautions be taken to avoid open flames or static electrical discharges that might cause fires.
- (2) Before use the container shall be opened and inspected; and when necessary the inside shall be scoured to remove any foreign matter or scale. The container shall be assembled and tested for leaks and, if no leaks are found, it shall be rinsed with alcohol and dried in an oven.
- (3) At the source of sample, the container shall be attached to the main supply in such a manner that the sample will be taken from the liquid contents of the original vessel. The valves at both ends of the container shall be opened and it shall be flushed with the sample until it is cold and the liquid sample emerges from the dip lug. All valves shall be closed and the montainer shall be disconnected from the source of supply:
- (4) With the container in an upright position, the valve attached to the dip leg shall be opened slowly and shall remain open until liquid ceases to emerge. The valve shall be closed and the protective covers shall be placed in position.

Composite Samples

- (1) If it be desired to take a sample representative of L.P. gas flowing for an extended period, the container shall be cleaned as usual, tested for leaks, filled with brine, and both valves shall be closed.
- (2) At the sampling point, the connecting line shall be purged with the liquid sample. The container shall be connected to the source of sample, making the connection to the dip leg of the container. (This is the reverse of the usual procedure). The valves on the sample source and the dip leg shall be opened

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APPENDIX 1

but the valve on the discharge end of the container shall remain closed.

- (3) Periodically the valve attached to the tube running to the bottom of the container shall be opened and a measured amount of brine shall be run out. The valve shall be closed and the procedure shall be ropeated at set intervals of time throughout the sampling period. (Note that by carrying out this procedure, the pressure inside the sample container will be kept equal to that of the main sample source and the container will receive the liquid sample. The L.P. gas will rise to the top of the container, thereby displacing a corresponding amount of brine through the tube which reaches to the bottom).
- (4) At the conclusion of the sampling period all valves shall be closed and the container shall be disconnected. The container shall be shaken thoroughly and then allowed to stand for a short period to settle the contents. The valve attached to the tube extending to the bottom of the container shall be opened and the brine shall be bled off so far as possible.
- (5) When the liquefied sample emerges from the opening the valve shall be closed. The valve attached to the dip leg shall be opened and allowed to remain open until no more liquid is discharged. The valve shall then be closed.

Procedure

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(1) The apparatus shall be set up in a sheltered place outside the laboratory. A portion of the liquid sample shall be purged through the valve attached to the tube extending to a metal coil which shall be immersed in an acetone bath. The bath shall be chilled by any convenient means such as the addition of solid carbon dioxide "ice" until the temperature of the liquid is not higher than minus 62°C.

It is imperative that this test be conducted in an isolated place outside the main laboratory building because of the extreme fire and explosion hazard should the glass flask containing the sample break during the test. Wherever the apparatus is assembled provision shall be made for the safe disposal of the vapours.

APPENDIX 1

- (2) When the temperature of the bath is below minus 62°C the 1-litre round-bottomed flask shall be immersed therein and allowed to come to the temperature of the bath. The flask shall be removed, wiped free of any liquid adhering to the outside, mounted in a cork ring on a trip scale, and shall be weighed to the nearest 0.1 gram. This weight shall be recorded. The liquid sample shall be admitted into the cold flask until it is about two thirds full. The flask shall be weighed again and the difference in weight shall be recorded as the weight of the sample taken for testing. The flask shall be attached to the contact column as shown in Figure 1. All the operations in the foregoing paragraph shall be conducted without delay.
- (3) Steam shall be admitted to the steam coil so that the liquid in the flask is just simmering. These conditions shall be maintained until the inside of the flask is practically dry. This operation should require approximately one to two hours.
- (4) When the inside of the tlask is practically dry the steam supply shall be shut off, the top of the contact column shall be opened, and about 75 ml. of the solvent shall be poured in and allowed to drain into the flask.

The column shall be removed from the flask, the bottom of the column shall be closed, and an additional 50 ml. of the solvent shall be added to the column. The inside of the column shall be rinsed thoroughly with this liquid, which shall then be added to the flask.

(5) The combined solvent washings shall be filtered into a tared anti-creeping beaker which shall be placed on a steam bath until the solvent has evaporated. When evaporation is complete the beaker shall be removed, and the outside wiped with a clean dry cloth. The beaker shall then be dried in an air oven for exactly 5 minutes at 105°C, cooled in a desiccator and re-weighed. The increase in weight of the beaker shall be noted and recorded.

Calculation

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(1) The weight of the sample shall be converted to the corresponding volume by dividing by the specific gravity of the liquid.

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(2) The amount of residue in the sample shall be computed by means

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 $R = \frac{W \times 100}{S}$

where

of the equation:

W = Weight of the residue in milligrams

S = Volume of sample in millilitres, as determined in the preceding paragraph

R = Residue in mg. per 100 ml. of liquid sample.

Report

The residue shall be reported as "_____mg. residue per 100 ml".

Safety Precautions

- (1) As stated previously, this test must not be conducted in any. room where other technicians are working, or in any area where smoking or open flames of any kind are permitted.
- (2) During the test the sample shall be heated at such a rate that the liquid in the glass flask will be just simmering.

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APPENDIX 2

NOTE 1

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Due to the possibility of olfactory fatigue, over odourisation is undesirable. Should the product, prior to odourisation, have a distinctive odour sufficient to comply with the odour level clause, then odourising agent should not be added.

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NOTE 2

It is noted that 0.6% methane in commercial propane could result in instability of certain appliances adjusted for utilising current product and supplied from bottles under low temperature conditions. For presently available liquefied petroleum gases, the vapour pressure specification would exclude the possibility of there being 0.6% or more methane in the liquid. However, in the unlikely possibility of alternative production methods being available which will result in the product containing 0.6% or more methane and complying with the specification in all respects, it will be necessary to consider the imposition of a limiting concentration for methane.

Issued 15/11/02

NOTE 3

Refer Explanatory Note 10 (a):

Revised 3/2/70

NOTE 4

To obtain true heating values, it would be necessary to determine separately and correct for, the water content of the sample, since the heating values in Appendix 3 are for completely dry gases. In order to avoid this additional and troublesome test, the following approximations have been adopted.

(a) For Commercial Propane -

It is assumed that the sample contains the maximum quantity of water permitted by the dryness test, which leads to the specific factor of 1.0004 for converting the heating value obtained in using values given in Appendix 3. Thus to the extent that the sample contains less than the permissible content of water, the heating value will be understated.

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APPENDIX 2

(b) For Commercial Butane and Butane-Propane Mixtures -

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Due to lack of data on the maximum water content of these gases, it is assumed for the purposes of these specifications that the gas phase is saturated with water. Hence the factor 1.0177 is used to convert the heating value, calculated from the values given in Appendix 3. to a saturated basis. Thus to the extent that the sample contains less than the saturated content of water, the heating value will be understated.

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APPENDIX 3

	Heating Value MJ / M ³ Dry 15°C, 101.325 kPa	Density Kgm / M ³ Dry 15 ⁰ C, 101.325 kPa
	REAL GAS	REAL GAS
Methane	37.76	0.680
Ethane	66.59	1.282
Propane	95.69	1.899
n-Butane	125.97	2.543
iso-Butane	125.14	2.534
n-Pentane	158.62	3.234
iso-Pentane	157.49	3.218
neo-Pentane	156.68	3.212
Ethene	60.05	1.194
Propens	88.54	1.809
1-Butene	118.63	2.448
2-Butene (cis)	118.26	2.446
2-Butene (trans)	118.08	2.446
iso-Butene	117.82	2.446
Water Vapour		0.787

(Refer Explanatory Note 7 for deviation of these data)

EXPLANATORY NOTES

(Issued 15/11/62, revised 3/2/70, 11/9/73)

(1) Definition of Liquefied Petroleum Gas

This was originally worded so as to be substantially uniform with that in the then draft S.A.A. Code for "The Storage and Handling of Liquefied Petroleum Gases", subsequently approved as AS CB20-1965.

(2) Format of Detailed Specification

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This was based when issued in 1962 on the Victorian Regulations rather than N.G.P.A. in having a general specification preceding supplementary specifications for each of the three grades. However, layout was somewhat changed from the Victorian to more clearly separate each of these.

Provision was made for 3 types of Liquefied Petroleum Gas corresponding with those in the Victorian Regulations and the N.G.P.A. Specifications at the time of original issue.

(3) Residue on Complete Evaporation

This appeared in the Victorian Regulations but not in N.G.P.A. or Western Australian Regulations when originally issued.

Some doubts were held by various members of the 1962 Committee on:

- (a) the need for any limit at all,
- (b) on the suitability of the method of test in the Victorian Regulations, and
- (c) as to what is a reasonable limit.

It was finally agreed with some reservations that a limit should be specified, to minimise deposits in vapourisers. Laboratory investigations of methods of test showed that if a low level such as specified in Victoria were retained then the Victorian method of test would have to be used, since the only available alternative, the proposed new ASTM Method which later became D2158, was not sufficiently sensitive. It was decided to recommend the same limit as in Victoria and the same method of test, although some members felt that this limit is unnecessarily low.

(4) Mercaptan Sulphur and Odour Level

(a) As in the N.P.G.A. Specifications, no reference is made to mercaptan content and this constitutes a difference from some State Regulations.

The reason for this is quoted from the minutes of the Technical Sub-Committee which investigated this matter: "reference to a maximum concentration of mercaptans should be deleted as the only reason for this is to avoid over-stenching. Mercaptans may not be the only odourant."

While eliminating this requirement, the 1962 Committee decided to include a cautionary note on over-odourisation. (See Appendix 2 Note 1).

- (b) Derivations of the noun "odour" rather than "stench" are used throughout for uniformity.
- (c) In the State Regulations in force at the time of original issue, the odour level requirement related to discharge from cylinders. In these Specifications the clause has been widened so as to embrace discharge from other pressure systems such as tanks and pipelines, and in addition to cover liquid spills which might persist under atmospheric pressure due to self-refrigeration.
- (d) Reference to "flammable limit" rather than "explosive limit" is used to conform with the practice of the S.A.A. Committee ME/15 covering standards for the Storage and Handling of Liquefied Perroleum Gas.

(5) Toxicity

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The wording used in the Victorian Regulations in 1962 was condensed by eliminating reference to specific uses, and also its application has been limited to toxicity by eliminating reference to safety. This latter term was considered too broad, and irrelevant in this context beyond the matter of toxicity.

(6) Definitions

Reference to the Mercury Freeze Test was replaced by the Weathering Test in line with N.G.P.A. practice at the time of original issue. In the 1970 revisions, composition by gas chromatography was adopted in line with revised N.G.P.A. practice for all grades.

(7) Heating Value - (all grades)

This does not appear in N.G.P.A. or other familiar overseas specifications but is usual in Government Regulations. There was fairly general doubt as to whether the inclusion of limits for Heating Value is necessary because of the controls on composition built into the specifications. It was finally agreed by the 1962

Committee that the inclusion of limits would facilitate Government acceptance having regard to the tradition of regulating the Heating Value of towns gas arising from its susceptibility to variation.

The original Committee decided to adopt the Victorian rather than Western Australian basis, i.e. Gross Calorific Value after vaporisation. However, while the Victorian limit of 21,000 B.T.U./lb was satisfactory for Commercial Propane. it was too high for Commercial Butane or Butane-Propane mixtures which might contain a substantial content of butylenes. Therefore for the latter grades a limit of 20,500 B.T.U./lb was adopted which is in line with the value for pure butylenes.

In the 1973 metrication revisions, the previous term "Calorific Value" was changed to "Heating Value", and the units were converted from British Thermal Units per pound avoirdupois at 60°F and 30 inches of mercury to megajoules per kilogram at 15°C and 101.325 kilopascals:

Opportunity was also taken to use more recent basic data for individual hydrocarbons than those originally obtained from B.S. 3156:1959. The new data are incorporated in the revision of Appendix 3 dated 11/9/73, their derivation being summarised as follows:

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- 1. Physical Constants of Hydrocarbons C1 to C10 A.S.T.M. Special Technical Publication No. 109A
- 2. British Standard 350: Part 1: 1959 Conversion Factors & Tables
- 3. Selected Values of Properties of Hydrocarbons National Bureau of Standards C 461

Facts:

1 B.T.U. = 1055.06 Joule (ref 2. P.32)
1 ft³ = 0.0283168 M³ (ref 2. P.33)
Heat of Combustion - He - (ref 1. P.30)
Compressibility Factor - Z - (ref 1. P.30)
Molar Volume = 22.4140 Litre Atmos/Mole at 0°C (ref. 3)
Molecular Weight (ref 1. P.30)

Assumption:

Compressibility Factor Z 60°F = Z 15°C

Heating Value Calculation:

MJ/M³, Dry = $\frac{\text{Hc } \times Z \times 1055.06 \times 519.67 \times 10^{-6}}{0.0283168 \times 518.67}$ 15°C, 101.325 kPa Real Gas = $\text{Hc } \times Z \times 0.037331$

Density Calculation:

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 Kgm / M^3 , Dry = $\frac{Molecular \ Woight \times 273.16}{22.414 \times Z \times 288.16}$ $15^{\circ}C$, 101.325 kPa Real Gas = $\frac{Molecular \ Woight}{Z} \times 0.042293$

(8) Vapour Pressure - (all grades - maxima)

The 1962 Committee adopted the N.G.P.A. practice of specifying maximum vapour pressure at 100°F rather than 130°F as in Victorian Regulations and 45°C (113°F) as in Western Australia. There were two advantages in operating at 100°F:

- (a) The N.G.P.A. and ASTM vapour pressure bombs were designed specifically for use at 100°F and may have become hydrostatic at higher temperatures.
- (b) This has been the normal temperature for vapour pressure temperature control baths in the Petroleum Industry and since this test is required on various products besides L.P.G. there was a substantial element of convenience involved.

In metricating this part of the specifications in 1973, the Committee wished to maintain a test temperature close to 100°F but which would be a simple number, and for this reason 40°C (104°F) was selected. Converted pressures were rounded off to the nearest 10 kilopascals to preserve the simple round numbers in p.s.i.g. which characterised the original specifications. It is estimated that the metric limits differs from the previous ones in p.s.i. at 100°F by only a small fraction of 1 p.s.i.

(9) 95% Boiling Point and Volatile Residue

The 1962 Committee adopted the revised N.G.P.A. practice of using a temperature of -37°F max. for Commercial Propane at standard pressure in place of the old Mercury Freeze Test.

The revisions of February 3, 1970 added compositional alternatives in line with ASTM and N.G.P.A. specifications, and also adopted the term "Volatile Residue" in place of "95% Boiling Point".

In metricating the temperature limits for the 95% boiling point for the 1973 revisions, the Committee rounded the temperatures to the nearest 1° C in the long term interests of simplicity.

(10) Dryness

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(a) Commercial Propane

The use of Cobalt Bromide and Dew Point Tests was followed by the 1962 Committee with reservations due to evidence of some lack of correlation between the two methods and doubt as to how effectively the tests relate to field performance.

The Committee has reviewed the possible use of the Valve Freeze Method, now ASTM D2713 but has no plans for its introduction at the time of the September 11, 1973 revisions.

(b) Commercial Butane

This requires only freedom from entrained water but the wording adopted in 1962 was substantially identical with that of N.G.P.A. rather than that of the Victorian Regulations which required the sample to be observed in a Dewar flask.

The Committee was not aware of any advantage in using a Dowar flask, whereas a disadvantage has been observed through it permitting the sample to refrigerate (due to evaporation) thereby freezing any moisture and making it hard to see.

(c) Butane-Propane Mixtures

The 1962 Committee felt that there was some gain in safety if the Victorian Regulations were followed in requiring the product to be treated as for Commercial Propane above a certain vapour pressure, rather than as for Commercial Butane at all vapour pressures which is the N.G.P.A. practice.

The dividing line was drawn at 170 p.s.i.g. at 100° F which in round figures was equivalent to that in the Victorian Regulations (i.e. 250 at 130° F).

(11) Designation - Propane-Butane Mixtures

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At the time of the original issue both N.G.P.A. and the Victorian Regulations required the maximum vapour pressure to be designated and limited the minimum vapour pressure to #5 p.s.i. below this.

Western Australia did not require designation but limited vapour pressure to 115 p.s.i.g. maximum at 45°C which is approximately 93 p.s.i.g. at 100°F, and in addition placed controls on composition which would have a bearing on vapour pressure.

The 1962 Committee considered control of the range of vapour pressure more practical than introduction of compositional analysis at that time and therefore followed the N.G.P.A. and Victorian approach. However, the narrow range used in these specifications could not be reconciled with the quality of the gas in general use in Western Australia where a range nearer to 20 p.s.i. would have been needed to accord with established practice. In addition and apart from the West Australia position, there could be important instances industrially where a narrow range such as 5 p.s.i. would be unnecessary and more costly.

The Committee accepted the principle that the main requirement is that both the maximum vapour pressure and the range of variation should be made known by suppliers to those concerned. It was agreed that the established practice of designating maximum vapour pressure be followed. It was also decided that the range of variation should be designated by the supplier rather than laid down in this specification, although one view leaned towards specifying a range. The agreed approach in effect leaves the buyer free to choose for himself a product of suitable vapour pressure range, and ensures that the relevant information is always available to him.

It was agreed that a satisfactory way to implement the foregoing was to require designation of both maximum and minimum vapour pressure; and for convenience a clause to this effect was consolidated with the clause limiting vapour pressure to 210 p.s.i.g. at 100°F.

(12) Composition

The position confronting the original Committee in 1962 was that N.G.P.A. did not have specific composition requirements. However, in Victoria and Western Australia, the Regulations stated that no methane shall be present, and in Western Australia there was a limit on \mathbf{C}_2 hydrocarbons. The Council of the Australian Liquefied Petroleum Gas Association was particularly anxious to resolve the methane question as the Victorian requirement of no methane could not be met in commercial practice. This arises from the fact that

some methane will always be present and the sensitivity of the method of analysis determines whether the laboratory result is nil or a positive amount. Gases which would have shown nil with equipment available when the Regulations were framed will no longer pass with modern equipment. The position therefore required either a positive limit to be imposed or elimination of reference to methane.

There was in fact a division of feeling originally as to whether any limit on methane was necessary; the question at issue being whether it could cause significant burner instability with possible hazards, after connecting a new supply of gas; and if so would not the vapour pressure limit prevent excessive amounts of methane being present.

A further matter for concern was the lack of standard methods of analysis in 1962 and the elaborate and costly nature of equipment for determining composition. This was at that time a serious objection to specifying limits on C_2 , C_{l_l} and higher hydrocarbons by analysis as against the familiar physical tests used by N.G.P.A. for example.

These problems were the subject of investigation by the Technical Sub-Committee which carried out considerable test work. This is available in report form.

The Sub-Committee's findings resulted in a decision to eliminate methane controls entirely since there appeared little likelihood of the small area of potential operating hazard being encountered. However the fact of its existence was recognised for future reference in Note 2 of Appendix 2.

(13) Hydrogen Sulphide

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At the time of original issue in 1962 both the Victorian and Western Australian Regulations imposed specific controls on this. Laboratory work carried out by the Technical Sub-Committee showed that the Corrosive Compounds (Copper Strip) Test adequately controls this. Copper Strip Tests on liquid L.P.G. were found by the investigating laboratory, to be more effective than the methods of testing the vapourised gas for HoS.

There were also some contentious aspects in regard to the manner of carrying out the test although these might have been resolved. It was generally believed that the two States in question followed coal gas practice in adding the $\rm H_2S$ test and in doing so probably did not allow for the fact that the protection of the copper strip test is

not available in towns gas testing. It was decided to follow N.G.P.A. practice thereby eliminating an unnecessary test.

(14) Miscellaneous Impurities

The Victorian Regulations in 1962 had a general requirement that L.P.G. must not contain impurities, the nature of which was not specified. This was not followed in the ALPGA specifications because modern high sensitivity analytical methods may demonstrate minute amounts of entirely harmless impurities. It was considered that if any likely impurity has to be guarded against it should be specified. Otherwise the public has the protection of the clauses relating to toxicity, vapour pressure, corrosiveness, and the calorific value which are the things most likely to be affected by unspecified impurities.

(15) Volatile Sulphur

The 1973 revision of this clause was primarily directed at metrication, including the adoption of metric standard conditions for measuring volume. All conversion factors used in metrication were obtained from the joint gas industry publication "Metric Units and Conversion Factors for use in the Australian Gas Industry".

Opportunity was taken to update the ASTM method to test method D2784 from D1266 which is not applicable to L.P.G. IP. 107 which is similar to D1266 was deleted.

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		Summary of Revisions	- September 11, 1973
	Page*	Subject	Nature of Revision
	General	Metrication	Metric (SI) units introduced throughout.
	3, 4 5	Committees Volatile Sulphur	Updated. Metric units introduced and test updated.
	6, 7, 8 6, 7, 8	Definition Heating Value	Methods of test updated. Name changed from Calorific Value. Metric units introduced with appropriate editorial changes. New correction factor provided for Propane, and introduced for first time for other grades.
13	6, 8, 9	Vapour Pressure	Metric units introduced.
	7, 8, 9	Volatile Residue	Metric units introduced. Obsolete IP Method 169/61T replaced by 264/72.
	79	NGPA Publication 2140 Dryness NGPA Publication 2140	ASTM Method updated. Date change to 1970 edition. Metric units introduced. Date change to 1970 edition.
	10	1 (a), 2, Fig. 1 2	Metric units introduced. Reference to Interstate Commerce Commission deleted as no longer needed.
	12 15, 16 17	Procedure (1) Note 4 Appendix 3	-80°F changed to 62°C Complete revision with metrication. Complete revision with metrication.
1	19	Item 4	Heading changed to "Mercaptan Sulphur and Odour Level". Volatile Sulphur is subject of a new note No.15 page 25.
	19	Heating Value	Previously "Calorific Value".
	20, 21	Heating Value	Adds explanation of 1973 changes in Specifications and Appendix 3.
į.	21	Vapour Pressure	Adds explanation of changes due to metrication.
	22 22	Volatile Residue Dryness - Commercial Propane.	Adds note on metrication. The note concerning the Valve Freeze Method is updated.
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Page numbers refer to this Edition and may not correspond to previous Edition.

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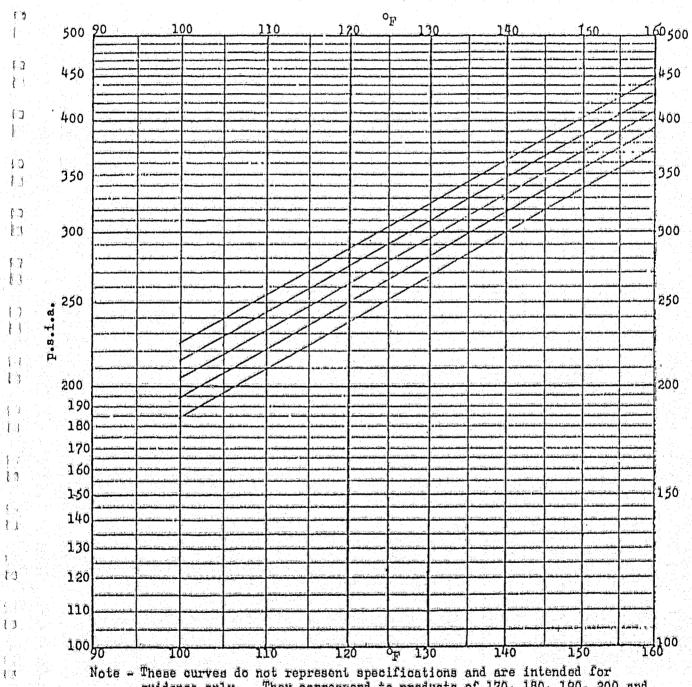
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ADDENDUM TO SPECIFICATIONS & TEST METHODS

COMMERCIAL PROPANE VAPOR PRESSURE - TEMPERATURE RELATIONSHIPS



Note - These curves do not represent specifications and are intended for guidance only. They correspond to products of 170, 180, 190, 200 and 210 psig vapor pressure at 100°F. (psig = psin - 14.7) Issued 14/2/67

INTERIM SPECIFICATION

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AUTOMOTIVE LPG

Issued Jointly by:

Australian Liquefied Petroleum Gas Association
Australian Institute of Petroleum Limited

PREFACE

This specification is issued jointly by:

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Australian Liquefied Petroleum Gas Association (ALPGA) Australian Institute of Petroleum Limited (AIP).

This specification is intended to apply to liquefied petroleum gas mixtures (LPG) marketed as fuel for vehicle engines designed or converted to run on LPG. It is based on the results of vehicle testwork carried out in Australia and overseas as detailed in the publication "Notes on ALPGA/AIP Specif'cation for Automotive LPG", available from the AIP.

DEFINITION OF LPG (LIQUEFIED PETROLEUM GAS)

The term LPG shall mean a material which is composed predominantly of any of the following hydrocarbons, or mixtures of all or any of them - propane, propylene, butanes and butylenes.

SPECIFICATION FOR AUTOMOTIVE LPG

PROPERTY	SPECIFICATION VALUE*	METHOD OF TEST
Corrosion, Copper Strip	No. 1 max.	ASTM D1838
Dienes, % vol.	0.5 max. (1)	ISO 7941 (D2163)
Dryness: a) if vapour pressure exceeds 1240 kPa gauge at 40°C b) other mixtures	Pass (2) No entrained water	GPA 2140 or D2713
	되고 말라면서 살았는 왜 제시하는	
Motor Octane Number (calculated)	92 min. (3)	ASTM D2598
Odour	Distinctive, unpleasant but non-persistent down to concentrations in air of 1/5 lower limit of flamability.	
Olefins, % vol.	Report (4)	ASTM D2163
Residue on Evaporation, mg/100 mL	2.0 max. (5)	Vic. Gas Act (App. 1)
Vapour Pressure @ 40°C, kPa gauge	800-1530 (6)	ASTM D1267
Volatile Residue: 95% evaporated temp. @ 760 mm Hg, °C	2 max. (7)	ASTM D1837
Volatile Sulphur: @ 15°C, dry and 101.325 kPa, mg/m'	340 max.	ASTM D2784
or and a Mittal Half of the Application of the Historica Half of the		表示 医毛术 人名英格兰 医连续 100 G (1) 11 (1) (1) (1) (1) (1) (1) (1) (1)

* bracketed figures refer to Notes

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- Butadienes are believed to be the major source of fuel system deposits.
- 2. In cases of dispute, method GPA 2140 (dew point) should be used.
- 3. ASTM D2598 does not list a MON blend value for butylenes. The value to be used in calculations is 82.0.

NOTES: (continued)

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- Olefins are lower octane components of LPG and are limited by the motor octane number specification.
- 5. The limit on residue is set to control fuel system deposits. Various test methods are available but testwork by the ALPGA has shown that the method specified in the Victorian Gas Act is the most sensitive.
- 6. Vapour pressure primarily influences cold starting ability. The value must be appropriate for the ambient conditions of use of the fuel.
- The value of 2°C max. limits pentanes and heavier hydrocarbons to approximately 2% vol. max

NOTES ON ALPGA/AIP SPECIFICATION FOR AUTOMOTIVE LPG

The ALPGA/AIP Interim Specification for Automotive LPG was arrived at by considering research work and experience from both Australia and overseas. These notes briefly summarise the basis of each specification point.

1. Corrosion Copper Strip

The specification of No. 1 max. (D1838) is equivalent to that of gasoline.

2. <u>Dienes</u>

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The specification of 0.5% vol. max. is identical to that in the proposed ISO specification (Reference 1), and draft British Standard BS4250 (Reference 2). A limit is required because as reported in the minutes of ISO Working Group 8 (Reference 3): "A number of countries report that minute concentrations or butadienes in LP-Gas will cause severe fouling and plugging of vaporiser equipment in automotive fuel applications".

3. <u>Dryness</u>

Two test conditions are listed.

Test a) applies to LPG that is high in C3 and contains relatively little C4. A visual est is impractical on such material because of the very high rate of vaporisation at room temperature and pressure. Dew point is the most appropriate test for such fuels. The valve freeze method (D2713) is a satisfactory field test but dew point should be used in cases of dispute.

Test b) applies to LPG that contains significant quantities of C4's. Such fuels can be readily viewed at ambient conditions and the presence of water is visually obvious.

4. Motor Octane Number

This number is defined to ensure adequate anti-knock characteristics of the fuel. Motor octane number (MON) is more critical than research octane number (RON) because of the higher mixture temperatures which occur with LPG in comparison with petrol. Engine performance under these conditions correlates better with MON. Also, because of the high sensitivity (difference between RON and MON), of LPG components, if MON is adequately defined RON will also be adequate.

The specification value of 92 min. was based largely on extensive testing by the British oil and motor industries (Reference 4) and similar work by European oil companies. This work showed that for an equivalent margin of anti-knock protection, the MON for LPG should

be 2 to 4 numbers higher than that for petrol. Australian premium grade petrols have MON's typically in the range 86-89.

The octane definition also imposes limits on the chemical composition of LPG. In particular it limits olefin content as olefins are relatively low in octane.

5. Odour

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An odourant is required to give a warning of leaks.

6. Olefins

This specification property generated the greatest debate in the preparation of the interim specification.

Concerns have been expressed over the potential for olefins to cause either fuel system deposits, component deterioration or engine knock. The problem of knock is covered by the definition of motor octane number (see discussion under 4. previously).

Field problems with deposits and embrittlement of components have been experienced at times with LPG, both locally and overseas. In order to assess the contribution of olefins to this problem it was originally planned to conduct experiments using a vapouriser test rig.

However research in Europe in the past few years has shown conclusively that olefins are not the cause of such problems. The main causes are the presence of dienes (particularly butadiene) and of compressor oils (carryover from gas compression equipment). This conclusion is reflected both in the ISO specification and the draft British Standard, neither of which impose a limit on olefins.

Based on the above, the decision was made to require that olefins be reported but that no specific limit be set. This allows users to be aware of the olefin content of the fuel they are purchasing. The problem areas identified in the European research regarding dienes and oil residues are covered in this specification by the limits on dienes (see 2. previously) and residue on evaporation (see 7. following).

7. Residue on Evaporation

This property is specified to limit the presence of low volatile impurities such as the compressor oil mentioned in 6. above.

There is a problem in defining a test method at the low level of residue required. The only widely used method is ASTM D2158 but this has very poor repeatability and reproducibility (Reference 3).

Page 3

The best method available was considered to be that developed by the ALPGA and incorporated into the Victorian Gas Act. Work was done by one Australian oil company (Reference 5) to assess the reproducibility of this method and it was found to be of the order of 0.3 mg/100 mL.

The allowable level of deposit was specified after consideration of international specifications. The value of 2.0 mg/100 mL max. compares with the ISO standard of approx. 2.8 mg/100 mL max. (actually specified as 50 mg/kg) and is much lower than the common specification using D2158 of about 28 mg/100 mL (0.05 mL per 100 mL of sample). A conservative approach was taken because of known field problems from compressor oil residues.

8. Vapour Pressure

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This property is specified to control both engine startability and variation in LPG composition, to avoid any need for engine retuning between fuels from different suppliers.

Consultants (EmTech Associates) were commissioned to study startability at low temperatures. Their conclusions (Reference 6) for blends of propane/butane are summarised below.

Ambient Temperature Max. Butane for Startability

-10	C			40%	***** 1
+ 2				70	VOT
+10				80	

Based on this work and experience in those European countries where large blend composition variations occur (eg. Holland and Italy), the decision was made to limit butane content to 60%. This allows startability down to about -2° C, satisfactory for the Australian climate, and avoids any need for retuning for driveability on switching between blends at the two extremes of the specification.

9. <u>Volatile Residue</u>

This property is specified to limit the amount of C5 and higher hydrocarbons to approximately 2% vol. maximum. This is in line with the ISO and draft British standards.

10. <u>Volatile Sulphur</u>

This property is limited to control corrosivity of the fuel and its combustion products. The value chosen is in line with overseas standards and experience with petrol.

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Standard Specification for FUEL OILS'

This standard is issued under the fixed designation D 396, the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last teapproval.

This method has been approved for use by agencies of the Department of Defense und for listing in the DaD Index of Specifications and Standards.

1.1 This specification (Note 1) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various clinatic and operating conditions.

Note 1—For information on the significance of the terminology and test methods used in this specification, see the Appendix.

1.2 This specification is for the use of purchasing agencies in formulating specifications to be included in contracts for purchases of fuel oils and for the guidance of consumers of fuel oils in the selection of the grades most suitable for their needs.

Note 2.—Nothing in this specification, shall pre-dude observance of federal, state, or local regulations which may be more restrictive.

1.3 The values stated in SI units are to be regarded as standard. The values stated in inchpound units are for information only.

2. Applicable Documents

- 2.1 ASTM Standards:
- D 56 Test Method for Flash Point by Tag Closed Tester
- D 86 Method for Distillation of Petroleum Products2
- D93 Test Methods for Flash Point by Pensky-Marlens Closed Tester² D95 Test Method for Water in Petroleum
- Products and Bituminous Materials by Distillation²
- D 97 Test Methods for Pour Point of Petrolcum Oils2
- D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)2

- D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test2
- D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)2
- D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)² D 473 Test Method for Sediment in Crude Oils and Fuel Oils by Extraction²
- D 482 Test Method for Ash from Petroleum Products2
- D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products²
 D 1266 Test Method for Sulfur in Petroleum
- Products (Lamp Method)2
- D 1352 Test Method for Sulfur in Petroleum
- Products (High-Temperature Method)²
 D 1659 Test Method for Maximum Fluidity
 Temperature of Residual Fuel Oil²
- D 1796 Test Method for Water and Sediment in Fuel Oils by Centrifuge Method (Laboratory Procedure)1
- D 2622 Test Method for Sulfur in Petroleum Products (X-Ray Spectrographic Method)3
- D 3245 Test Method for Pumpability of Industrial Fuel Oils4

¹ This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.
Current edition approved Aug. 29, 1980, Published October 1980, Originally published as D 396 – 34 T. Last previous edition D 396 – 79,

3. Annual Book of ASTM Standards, Vol 05.01.

2 Discontinued, see 1983 Annual Book of ASTM Standards, Vol 05.01

Vol 05.01.

Annual Book of ASTM Standards, Vol 05.02.

Annual Book of ASTM Standards, Vol 05.03.

D 396

3. General Requirements

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3.1 The grades of fuel oil specified herein shall be homogeneous hydrocarbon oils, free from inorganic acid, and free from excessive amounts of solid or fibrous foreign matter likely to make frequent cleaning of suitable strainers

necessary.

3.2 All grades containing residual components shall remain uniform in normal storage and not separate by gravity into light and heavy oil components outside the viscosity limits for the grade.

4. Detailed Requirements

4.1 The various grades of fuel oil shall conform to the limiting requirements shown in Table I.

4.2 Modifications of limiting requirements to meet special operating conditions agreed upon between the purchaser, the seller, and the supplier shall fall within limits specified for each grade, except as stated in supplementary footnotes for Table 1.

5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM methods," except as may be required under 5.1.1.

5.1.1 Flash Point.—Method D 93, except where other methods are prescribed by law for the determination of minimum flash point. For Grades No. 1 and No. 2, Method D 56, may be used as an alternative with the same limits, provided the flash point is below 79.4°C

(175°17) and the viscosity is below 5.8 eSt (45 SUS) at 38°C (100°F). This method will give slightly lower values. In cases of dispute, Method D 93 shall be used as the referee method.

5.1.2 Pour Point - Method D 97, Alternative test methods that indicate flow point properties may be used for low sulfur residual fuels by agreement between purchaser and supplier.
5.1.3 Water and Sediment - The water and

sediment in Grades Nos. 1, 2, 4, and 5 shall be determined in accordance with Method D 1796 and Grade No. 6 by Method D 95, and Method

5.1.4 Carbon Residue Method D 524.

5.1.5 Ash Method D 482.

5.1.6 Distillation - Distillation of Grade No. I and No. 2 oils shall be determined in accordance with Method D 86,

5.1.7 Piscosity - Viscosity shall be determined in accordance with Method D 445.

5.1.8 Gravity—Method D 287. 5.1.9 Corrosion—Method D 130, 3 h test at 50°C (122°F).

5.1.10 Sulfur-The sulfur content of any grade may be determined by any of the following methods: Method D 129, Method D 1552, or Method D 2622, In addition, the sulfur of Grade No. I may be determined by Method D 1266.

For information on the precision of the ASTM methods of test for fuel oils refer to "An Evaluation of Methods for Determination of Sulfur in Fuel Oils" by A. R. Crawford. Esso Mathematics & Systems line, and Ö. V. Dyroff, Esso Research and Engineering Co., 1969. This document is available from the Publications Section. American Petroleum Institute, 2101 L. St., N.W., Washington, D.C., 20037.

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Ash., weight 10%. % Point	duc Ash. on weight 10% bit. Point 5000%	Ash., weight 10%. % Point	10% Point		L L	90% Point	Universal at 38°C (100°F)	The second secon	Furol at 50°C (122°F)	υ ₀ ,	At 38°C (100°F)	ů.E	At 40°C (104°F)		At 50°C (122°F)		Specific Cop- Gravity per S 50/60°F Strip (deg Corro- API) sion	Sul- für,
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		Grade of Fuel Oil		No & Hearn	Preheating may be re-	may be required for handling	No. 6 Preheating required (for burning and han-	ding

TABLE 1 Continued

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** It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next fower grade unless in fact it meets all fower grade.

To would the lower grade of the minimum 90% point shall be waived.

To work or higher pour points may be specified whenever required by conditions of storage or use. When pour point less than —18°C (0°F) is specified, the minimum wiscosity for by storage or a serior for information only and not necessarily limiting.

The mount of water by distillation plus to the sediment by extraction shall not exceed 0.50 %. A deduction in the lower lower sulfur fact oil is required, fact oil falling in the viscosity range of a lower numbered grade down to and including No. 4 may be supplied by agreement between there have and supplier. The viscosity range of the initial shipment shall be invariantless and upplier. The viscosity range of the initial shipment shall be invariantless as minimum heating values and also prevents misrepresentation and missipplication of this product as Grade No. 2.

Where flow sulfur fact oil is required. Grade 6 fact oil will be classified as fow pour +13°C (60°F) max or high pour (no reax). Low pour fact oil should be used unless all tanks and fines are heated.

APPENDIX

XI. SIGNIFICANCE OF ASTM SPECIFICATION FOR FUEL OILS

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M.I. Scope

X1.1.1 ASTM Specification D 396 divides fuel wis into grades based upon the types of burners for which they are suitable. It places limiting values on everal of the properties of the oils in each grade, The properties selected for limitation are those that are believed to be of the greatest significance in determing the performance characteristics of the oils in the types of burners in which they are most commonly used.

XL2 Classes

X1.2 Classes

X1.2.1 Because of the methods employed in their production, fuel oils fall into two broad classifications: distillates and residuals. The distillates consist of overhead or distilled fractions. The residual are bottoms remaining from the distillation, or blends of these bottoms with distillates. In Specification D 396, Grades No. 1 and No. 2 are distillates and the grades from No. 4 to No. 6 are usually residual, although some heavy distillates may be sold as Grade No. 4.

XIA Grades

XI.3.1 Grade No. I is a light distillate intended for use in burners of the vaporizing type in which the oil is converted to a vapor by contact with a heated surface or by radiation. High volatility is necessary so ensure that evaporation proceeds with a minimum of tesidue.

of this that evaporation proceeds with a minimum of tesidue,

X1.3.2 Grade No. 2 is a heavier distillate than trade No. 1. It is intended for use in atomizing type burners which spray the oil into a combustion chamber where the tiny droplets burn while in suspension. This grade of oil is used in most domestic burners and in many medium capacity commercial-industrial burners where its ease of handling and ready availably sometimes justify its higher cost over the residual tiels.

X1.3.3 Grade No. 4 (Light) is usually a light residual but it sometimes is a heavy distillate. It is intended to use both in pressure-atomizing commercial-injurial burners not requiring higher cost distillates that in burners equipped to atomize sits of higher necestly. Its permissible viscosity range allows it to be pumped and atomized at relatively low storage table of higher viscosity than domestic burners can usele. Its permissible viscosity range allows it to be burners equipped with devices that atomize its of higher viscosity than domestic burners can usele, its permissible viscosity range allows it to be burned and atomized at relatively low storage temberatures. Thus, in all but extremely cold weather it requires no preheating for handling.

X1,3.5 Grade No. 5 (Light) is residual fuel of intermediate viscosity for burners capable of handling fuel more viscous than grade No. 4 without preheating. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.6 Grade No. 5 (Heavy) is a residual fuel more viscous than Grade No. 5 (light) and is intended for use in similar service. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.7 Grade No. 6, sometimes referred to as "Bunker" is a high-viscosity oil used mostly in commetant and industrial heating. It requires preheating in he storage tank to permit pumping, and additional preheating at the burner to permit atomizing. The extra equipment and maintenance required to handle this fuel usually preclude its use in small installations.

X1.3.8 Residual fuel oil supplied to meet regulations requiring low sulfur content may differ from the grade previously supplied. It may be lower in viscosity (and fall into a different grade number). If it must be fluid at a given temperature, Method D 97 may not accurately reflect the pour point which can be expected after a period of storage, It is suggested that the purchaser and supplier discuss the proper handling and operating techniques for a given low-sulfur residual fuel oil in the installation where it is to be used.

X.1.4 Significance of Test Methods

X.1.4.1 The significance of the properties of fuel oil on which limitations are placed by the specifica-

oil on which limitations are placed by the specifica-tion is as follows:

X1.4.1.t Flash Point—The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state, or municipal laws and is based on accepted practice in handling and

and is based on accepted practice in nanuing and use.

XI.4.1.2 Pour Point—The pour point is an indication of the lowest temperature at which a fuel oil can be stored and still be capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point may occur when residual fuel oils are subjected to cyclic temperature variations that may occur in the course of storage or when the fuel is preheated and returned to storage tanks. To predict these properties, test methods such as British Admiralty Method VII, Method D 3245-IP 230/69

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or Method D 1659, may be required.

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or Method D 1659, may be required.

X1.4.1.3 Water and Sediment—Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstruction to flow of oil from the tank to the burner. Water in distillate fuels may cause corrosion of tanks and equipment and it may cause emulsions in residual fuels.

X1.4.1.4 Carbon Residue—The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are varporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in vaporizing burners, such as pot-type and sleeve-type burners, where the fuel is vaporized in an air-deficient atmosphere.

To abtain measurable values of carbon residue in

where the fuel is vaporized in an air-deficient atmosphere.

To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90 % of it in accordance with ASTM Method D 86. Test for Distillation of Petroleum Products, and then determine the carbon residue concentrated in the remaining 10 % bottoms.

X1.4.1.5 Ash—The amount of ash is the quantity of noncombustible material in an oil. Excessive amounts may indicate the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

X1.4.1.6 Distillation—The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10 % and 90 % distilled temperatures are specified for grade No. 1 fuel. The limiting 10 % value assures easy starting in vaporizing type burners and the 90 % limit excludes heavier fractions that would be difficult to vaporize.

The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations, Distillation limits are not specified for fuel oils of grades Nos. 4, 5, and 6.

XI.4.1.7 Viscosity Limits for Grades Nos. 1 and 2—The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or may be pumped, and the ease of atomization

indicates both the relative ease with which the oil will flow or may be pumped, and the ease of atomization.

Viscosity limits for No. 1 and No. 2 grades-are specified to help maintain uniform fuel flow in appliances with gravity flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater,

X1.4.1.8 Gravity—Gravity alone is of little signif-

reheater, X1.4.1.8 Gravity—Gravity alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties, it is of value in weight-volume relationships and in calculating the heating value of an oil.

oil.

X1.4.1.9 Corrosion—The corrosion test serves to indicate the presence or absence of materials that might corrode copper, brass, and bronze components of the fuel system. This property is specified only for No. 1 distillate fuel.

X1.4.1.10 Limited sulfur content of fuel oil may be required for special uses in connection with heat treatment, nonferrous metal, glass, and ceramic furnaces or to meet federal, state or local legislation of regulations. regulations.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard its subject to revision at any time by the tesponsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for udditional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

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Standard Specification for DIESEL FUEL OILS'

this standard is issued under the fixed designation D 975; the number immediately following the designation indicates the state of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last experience. A superscript epsilon (c) indicates an editorial change since the last revision or reapproval.

Note—New Section 2 was editorially added and subsequent sections renumbered; also Figs. X2.1 through X2.12 were shortally changed in May 1782.

1. Scope

1.1 This specification covers three grades of diesel fuel oils suitable for various types of desel engines.

1.2 This specification, unless otherwise proided by agreement between the purchaser and the supplier, prescribes the required properties oldiesel fuels at the time and place of delivery.

Note I-Nothing in this specification shall pre-adeobservance of federal, state, or local regulations shich may be more restrictive.

1.3 The values stated in SI units are to be egarded as the standard. The values stated in sch-pound units are for information only.

1. Applicable Documents

21 ASTM Standards;

D56 Test for Flash Point by Tag Closed Tester2

D86 Method for Distillation of Petroleum Products2

D93 Tests for Flash Point by Pensky-Martens Closed Tester

D 129 Test for Sulfur in Petroleum Products (General Bomb Method)3

D130 Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test⁶

D 445 Test for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)⁵

D482 Test for Ash from Petroleum Products⁶ D 524 Test for Ramsbottom Carbon Residue of Petroleum Products6

D613 Test for Ignition Quality of Diesel Fuels

by the Cetane Method?

D 976 Calculated Cetane Index of Distillate Fuels⁶

D 1500 Test for ASTM Color of Petroleum Products (ASTM Color Scale)

D 1796 Test for Water and Sediment in Crude Olls and Fuel Oils by Centrifuge⁸
D 2161 Conversion of Kinematic Viscosity to

Saybolt Universal Viscosity or to Saybolt Furol Viscosity" D 2274 Test for Oxidation Stability of Distil-

late Fuel Oil (Accelerated Method)⁸
D 2276 Test for Particulate Contaminant in

Aviation Turbine Fuels*

D 2500 Test for Cloud Point of Petroleum Oils

D 2880 Specification for Gas Turbine Fuel Oils⁸

D 3117 Test for Wax Appearance Point of Distillate Fuels10

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products10

3. Regulrements

3.1 The grades of diesel fuel oils herein spec-

This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Froducts and Lubricants.

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Annual Book of ASTM Standards, Vol 05.02.

Annual Book of ASTM Standards, Vol 05.02.

Annual Book of ASTM Standards, Vol 05.03.

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ified shall be hydrocarbon oils conforming to the detailed requirements shown in Table 1.

4. Test Methods

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4.1 The requirements enumerated in this specification shall be determined in accordance with the following methods:

4.1.1 Flash Point—Method D 93, except where other methods are prescribed by law. For Grades No. 1-D and No. 2-D, Method D 56, may be used as an alternate with the same limits, provided the flash point is below 79°C (175°F) and the viscosity is below 5.5 eSt (or mm²/s)¹¹ at 40°C (104°F). This method will give slightly lower values. In cases of dispute, Method D 93 shall be used as the referee method.

4.1,2 Cloud Point-Method D 2500, Method

D 3117 may also be used since the two an closely related. In case of dispute Method D 2500 shall be the referee method.

4.1.3 Water and Sediment-Method D 179

4.1.4 Carbon Residue—Method D 524,
4.1.5 Ask—Method D 482,
4.1.6 Distillation of No. 1-D and No. 2.1
Fuel Oils—Method D 86,
4.1.7 Viscosity—Method D 445 or by cot.

version in accordance with Method D 2161.

4.1.8 Sulfur—Method D 129. 4.1.9 Corrosion—Method D 130, 3 h lest i

4.1.10 Cetane Number-Method D 613.

¹¹ One centistokes (IcSt) equals one millimetre squire, per second (1 mm³/s); therefore, the two units are more changeable.

			TABLE	1 Detaile	d Requir	ements fo	TABLE 1 Detailed Requirements for Diesel Fuel Oils AM	rel Oils ^{A.H}						
		-10.00				2	Distillant							
Grade of Diesel Fuel Oil	Point.	Cloud Point °C	Water and Sed- incol	Cloud and Sed. Residue Ash, Tempe Point °C iment on 10% weight °C	Ash. weight	T. C.	Temperatures, °C (°E)		Visc	Viscosity		śulfar.	Copper	
	E		٠٠٥ ر چ	Kesid- uum, Æ	V#	σ.	90 ⊊ Point	Kinemat 40	Kinematic Steat Saybolt, SUS at	Saybolt	olt, SUS at	Magh.	Sion Sion	Num.
	Z.	1		:					,	3				
		A PAGE	Max	Max	N. Z.X	Min	Mar	Min	7					
No. 1-D A volatile distillate fuel oil for	38	**	300	910	0.65	I	4.		1	ulle	Max	Max	Max	Min
engines in service requiring (100)	(1001)				100	:	288	2	7.7		34.4	0.50	No. 3	40.
frequent speed and load			11.7%				4000		*****	4 (14) (2)				2
No. 2-D A distillate fuel oil of lower 57	23	la,	200						***************************************	****		Managar		
volatility for engines in indus-	(125)		3	ĵ	100	282	338	61	7	32.6	40.1 0.50	0.50	No 1	ADF.
Mo 4 D 4 6 1 1 1 1						(A)	9		er Arcigie					ř
Speed engines.	55	£ :	050	:	0.10		:	5.5	240	950	176.0	-		
			-			Marie .				1	2	7.0	:	30

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* To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller, and manufacturer.

It is unrealisation specify low-temperature properties that will ensure satisfactory operation on a broad basis. Satisfactory operation should be achieved in most cases if the cloud point (or was appearance points is specified at 6°C above the tenth percentile minimum anbient temperature for the united States are shown in Appendix X2. This guidance is of a general nature; some equipment designs, use flow improver additives, fuel between the finel supplier; and generated for the indianal minimum and properties of the united States are shown in Appendix X2. This guidance is of a general nature; some equipment designs, use flow improver additives, fuel between the finel supplier; and generated for the indianded use and expected analytical temperatures.

**When cloud point less than -12°C (10°F) is specified, the minimum without is a like to a minimum without and apply.

**The countries outside the United States, other sulfur limits may apply.

**The cetane number by Method D 613 is not available. Method D 976 may be used as an approximation. Where there is disagreement. Method D 613 shall be the referee

method.

**Low-atmospheric temperatures as well as engine operation at high altitudes may require use of fuels with higher cetane ratings.

**LoSt=1* mm2/s.

**The values stated in SI units are to be regarded as the standard. The values in inch-pound units are for information only.

APPENDIXES

XI. SIGNIFICANCE OF ASTM SPECIFICATION FOR DIESEL FUEL OILS

XI.1 Introduction

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X1.1.1 The properties of commercial fuel oils depend on the refining practices employed and the nature of the crude oils from which they are produced. Distillate fuel oils, for example, may be produced within the boiling range of 150 and 400°C (300 and 735°C) having many possible combinations of various properties such as volatility, ignition quality, viscosity, and other characteristics.

X1.2 Grades

X1.2 Grades

X1.2.1 Specification D 975 is intended as a statement of permissible limits of significant fuel properties used for specifying the wide variety of commercially available diesel fuel oils. Limiting values of significant properties are prescribed for three grades of diesel fuel oils. These grades and their general applicability for use in diesel engines are broadly indicated as follows:

X1.2.2 Grade No. 1-D—Grade No. 1-D comprises the class of volatile fuel oils from kerosine to the Intermediate distillates. Fuels within this grade are applicable for use in high-speed engines in services involving frequent and relatively wide variations in loads and speeds, and also for use in cases where abnormally low fuel temperatures are encountered.

X1.2.3 Grade No. 2-D—Grade No. 2-D includes the class of distillate gas oils of lower volatility. These fuels are applicable for use in high-speed engines in services involving relatively high loads and uniform speeds, or in engines not requiring fuels having the higher volatility of other properties specified for Grade No. 1-D.

X1.2.4 Grade No. 4-D—Grade No. 4-D covers the class of more viscous distillates and blends of these distillates with residual fuel oils. These fuels are applicable for use in low- and medium-speed engines employed in services involving sustained loads at substantially constant speed.

X1.3 Selection of Particular Grade

X1.3 Selection of Particular Grade

X1.3.1 The selection of a particular diesel fuel oil from one of these three ASTM grades for use in a given engine requires consideration of the following factors:

X1.3.1.1 Fuel price and availability,
X1.3.1.2 Maintenance considerations,
X1.3.1.3 Engine size and design,
X1.3.1.4 Speed and load fanges,
X1.3.1.5 Frequency of speed and load changes, and

and
X1.3.1.6 Atmospheric conditions.
Some of these factors may influence the required fuel properties outlined as follows:

X1.4 Cetane Number

X1.4.1 Cetane number is a measure of the ignilion quality of the fuel and influences combustion roughness. The cetane number requirements depend on engine design, size, nature of speed and load vanitions, and on starting and atmospheric conditions increase in cetane number over values actually required does not materially improve engine performance. Accordingly, the cetane number specified should be as low as possible to assure maximum fur, availability.

X1.5.1 The fuel volatility requirements depend of engine design, size, nature of speed and load vanitions, and on starting and atmospheric conditions. For engines in services involving rapidly fluctuating loads and speeds as in bus and truck operation, the more volatile fuels may provide best performance particularly with respect to smoke and odor. However, best fuel economy is generally obtained from the heavier types of fuels because of their higher hear content.

X1.6 Viscosity

X1.6.1 For some engines it is advantageous to specify a minimum viscosity because of power lost due to injection pump and injector leakage, Mathematical specifications involved in engine design and size and the characteristics of the injection system.

X1.7 Carbon Residue

X1.7.1 Carbon residue gives a measure of the carbon depositing tendencies of a fuel oil when heated in a bulb under prescribed conditions. While not directly correlating with engine deposits, the property is considered an approximation.

X1.8 Sulfur

X1.8.1 The effect of sulfur content on engine wer and deposits appear to vary considerably in importance and depends largely on operating conditions in order to assure maximum availability of fuels, the permissible sulfur content should be specified as high as practicable, consistent with maintenance considerations.

X1.9 Flash Point

X1.9.1 The flash point as specified is not directly related to engine performance. It is, however, of

importance in connection with legal requirements and safety precautions involved in fuel handling and storage, and is normally specified to meet insurance and fire regulations.

XI.10 Cloud Point

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X1.10.1 Cloud point is of importance in that it defines the temperature at which a cloud or haze of exit crystals appears in the oil under prescribed test conditions which generally relates to the temperature it which wax crystals begin to precipitate from the oil in use.

X1.11 Ash

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XI.11.1 Ash forming materials may be present in fuel oil in two forms: (1) abrasive solids, and (2) soluble metallic soaps. Abrasive solids contribute to injector, fuel pump, piston and ring wear, and also to engine deposits. Soluble metallic soaps have little effect on wear but may contribute to engine deposits.

X1.12 Copper Strip Corrosion

X1.12.1 This test serves as a measure of possible difficulties with copper and brass or bronze parts of the fuel system.

X2. TENTH PERCENTILE MINIMUM AMBIENT TEMPERATURES FOR THE UNITED STATES (EXCEPT HAWAII)

V2.1 Introduction

X2.1 Introduction

X2.1.1 The tenth percentile minimum ambient temperatures shown on the following maps (Figs. X2.1 through X2.12) were derived from an analysis of historical hourly temperature readings recorded wer a period of 15 to 21 years from 345 weather stations in the United States. This study was conducted by the U.S. Army Mobility Equipment Research and Development Center (USAMERDC), Coating and Chemical Laboratory, Aberdeen Proving Ground, Md. 21005. The tenth percentile minimum ambient temperature is defined as the lowest temperature which will occur 90 % of the time. In other words, there is only a 10 % expectation that the minimum daily temperature will be lower than the tenth percentile minimum temperature.

X2.1.2 It is recommended that these data be used to estimate the temperature to be used in specifying

X2.1.2 It is recommended that these data be used to estimate the temperature to be used in specifying low temperature operability requirements. In establishing these low-temperature operability requirements consideration should be given to fuel system design, normal equipment protection for cold seather operation, type of operation, use of fluidity traptover additives, area in which the fuel will be used and any unusual weather or operating conditions, or a combination thereof, which may make low temperature operability more or less severe than normal.

X2.2.1 The maps in the following figures were derived from CCL Report No. 316, "A Predictive Study for Defining Limiting Temperatures and Their

Application in Petroleum Product Specifications, "by John P. Doner. This report was published by the U. S. Army Mobility Equipment Research and Development Center (USAMERDC), Coating and Chemical Laboratory, and it is available from the National Technical Information Service, Springfield, Va. 22151, by requesting Publication No. AD756-420. X2.2.2 Where states are divided the divisions are

x2.2.2 Where states are divided the divisions are noted on the maps with the exception of California which is divided by counties as follows:
California, North Coast—Alameda, Contra Costa, Del Norte, Humbolt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, Tabelio.

Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, Trinity.
California, Interior—Lassen, Modoc, Plumas, Sierra, Siskiyou, Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Fresno, Glenn, Kern (except that portion lying east of the Los Angeles County Aqueduct), Kings, Madera, Mariposa, Merced, Placer, Sacramento, San Joaquin, Shasta, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo, Yuba, Nevada.

vada.
California, South Coast—Orange, San Diego, San Luis Obispo, Santa Batbara, Ventura, Los Angeles (except that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct).
California, Southeast—Imperial, Riverside, San Bernardini, Los Angeles (that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct), Mono, Inyo, Kern (that portion lying east of the Los Angeles County Aqueduct).

X3, LONG-TERM STORAGE OF DISTILLATE FUELS

XJ.1 Scope

X3.1.1 This appendix provides guidance for con-umers of distillate fuels who may wish to core quantities of fuels for extended periods. Fuels con-taining residual components are excluded. Consis-tently successful long-term fuel storage requires at-tention to fuel selection, storage conditions, and mon-noting of properties prior to and during storage.

X3.1.2 Normally produced fuels have adequate stability properties to withstand normal ctorage without the formation of troublesome amounts of insoluble degradation products. Fuels that are to be stored for prolonged periods should be selected to avoid formation of sediments, which can overload filters or plug combustor nozzles or injectors. Selection of these fuels should result from supplier-user discussions.

X3.1.3 These suggested practices are general in nature and should not be considered substitutes for any requirements imposed by the warranty of the distillate fuel equipment manufacturer or by federal, state, or local government regulations. Although they cannot replace a knowledge of local conditions or a good engineering and scientific judgment, these suggested practices do provide guidance in developing an individual fuel management system for the distillate fuel user. They include suggestions in the operation and maintenance of existing fuel storage and handling facilities and for identifying where, when, and how fuel quality should be monitored.

X3.2 Definitions

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X3.2.1 long-term storage—storage of fuel for longer than 12 months after it is received by the user, X3.2.2 bulk fuel—fuel in the storage facility. X3.2.3 combustor fuel—fuel entering the combustion zone of the burner or engine after filtration or other treatment of bulk fuel. X3.2.4 fuel contaminants—foreign materials that make fuel less suitable or unsuitable for the intended 43c. Fuel contaminants include materials introduced subsequent to the manufacture of fuel and fuel degradation products.

subsequent to the manufacture of fuel and fuel degradation products.

X3.2.5 fuel-degradation products—those materials which are formed in fuel during extended storage. Insoluble degradation products may combine with other fuel contaminants to reinforce deleterious effects. Soluble degradation products (soluble gums) are less volatile than fuel and may carbonize to form in fuels due to complex interactions and oxidation of small amounts of ofelinic, sulfurous, oxygenated, and nitrogenous compounds present in fuels. The formation of degradation products may be catalyzed by dissolved metals, especially copper salts.

X3.3 Fuel Selection

X3.3. Fuel Selection

X3.3.1 Certain distilled refinery products are generally more suitable for long-term storage than others. The stability properties of distillates are highly dependent on the crude oil sources, severity of processing, and whether additional refinery treatment has been carried out.

X3.3.2 The composition and stability properties of distillate fuels produced at specific refineries may be different. Any special requirements of the user, such us long-term storage, should be discussed with the supplier.

the supplier.

X3,3,3 Blends of fuels from various sources may interact to give stability properties worse than expected based on the characteristics of the individual

X3.4 Fuel Additives

X3.4 Fuel Additives

X3.4.1 Available fuel additives can improve the suitability of marginal fuels for long-term storage but may be unsuccessful for fuels with markedly poor stability properties. Most additives should be added at the refinery or during the early weeks of storage to obtain maximum benefits.

X3.4.2 Biocides or biostats destroy or inhibit the growth of fungiand bacteria which can grow at fuel-

water interfaces to give high particulate concentrations in the fuel. Available blocides are soluble a both the fuel and water or in the water phase only

X3.5 Tests for Fuel Quality

X3.5.1 Tests for Fuel Quality

X3.5.1 At the time of manufacture, the storage stability of fuel may be estimated by Method D 22° thowever, correlation of this test with actual storage stability may vary significantly, depending upon fig. conditions and fuel composition.

X3.5.2 Performance criteria for accelerated stability tests that assure satisfactory long-term storage, fuels have not been established.

X3.6 Fuel Monitoring

X3.6.1 A plan for monitoring the quality of but fuel during prolonged storage is an integral part of successful program. A plan to replace aged fuel with fresh product at established intervals is also desirable X3.6.2 Stored fuel should be periodically sample, and its quality assessed. Method D 270, provides guance for sampling. Fuel contaminants and degradation of the sample will usually settle to the bottom of a quiexciank. A "Bottom" or "Clearance" sample, as defined Practice D 4057, should be included in the evaluation along with an "All Level" sample.

X3.6.3 The quantity of insoluble fuel contaminants present in fuel can be determined using Method D 2276, Procedure A.

X3.6.4 Other quality tests like fuel color (Method D 1500) and stability tests (Method D 2274) afterstorage may have value. Correlations of these tea with fuel suitability are tenuous.

X3.7 Fuel Storage Conditions

X3.7. Fuel Storage Conditions

X3.7.1 Contamination levels in fuel can be it-duced by storage in tanks kept free of water, are tankage should have provisions for water draininger a scheduled basis. Water promotes corrosion, are microbiological growth may occur at a fuel-water interface. Underground storage is preferred to avoid temperature extremes; above-ground storage tankshould be sheltered or painted with reflective paintligh storage temperatures accelerate fuel degradation. Fixed roof tanks should be kept full to limit oxygen supply and tank breathing.

X3.7.2 Copper and copper-containing alleves should be avoided. Copper may promote fuel degradation and may produce mercaptide gels. Zincoatings may react with water or organic acids in latifuel to form gels which rapidly plug filters.

X3.7.3 Appendix X3 of Specification D 2880, ducussed fuel contaminants as a general topic.

X3.8 Use of Degraded Fuels

X3.8.1 Puels that have undergone mild-to-moderate degradation may often be consumed in a normal way, depending on the fuel system requirements Filters and other cleanup equipment may require special attention and increased maintenance. Burner nozzle or injector fouling may occur more rapidly.

X3.8.2 Fuels containing very large quantities of fuel degradation products and other contaminants.

sith runaway microbiological growth require special attention. Consultation with experts in this area is desirable, it may be possible to drain the sediment or draw off most of the fuel above the sediment layer

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and use it with the precautions described in X3.8.1, However, very high soluble gum levels or corrosion products from microbiological contamination may cause severe operational problems.

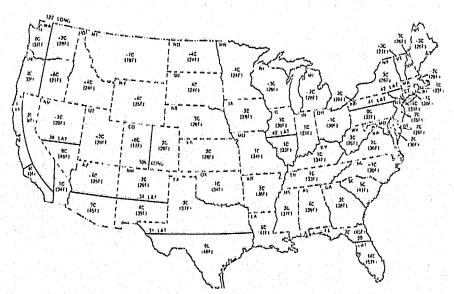


FIG. X2.1 October-10th Percentlle Minimum Temperatures

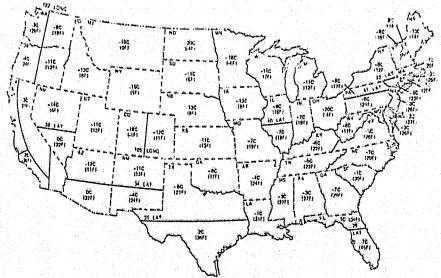
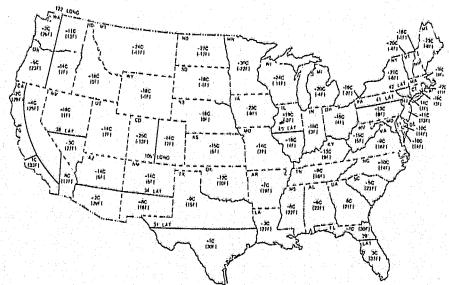


FIG. X2.2 November-10th Percentile Minimum Temperatures





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FIG. X2.3 December—10th Percentlle Minimum Temperatures

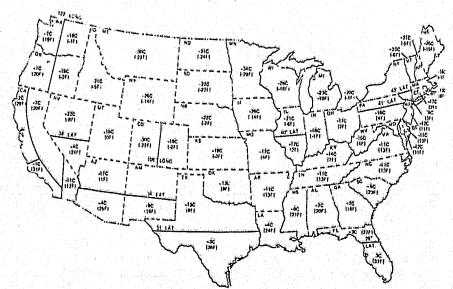


FIG. X2.4 January-10th Percentille Minimum Temperatures



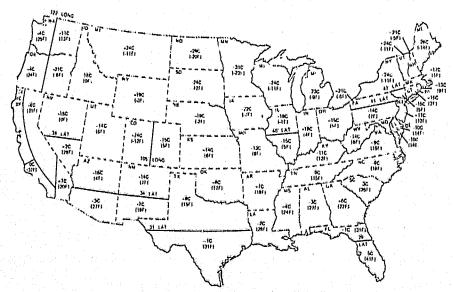


FIG. X2.5 February-10th Percentille Minimum Temperatures

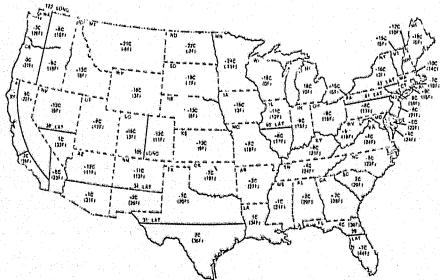


FIG. X26 March-10th Percentile Minimum Temperatures

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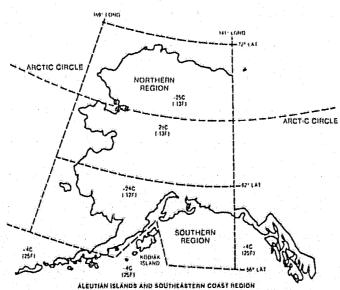


FIG. X2.7 October-10th Percentile Minimum Temperatures

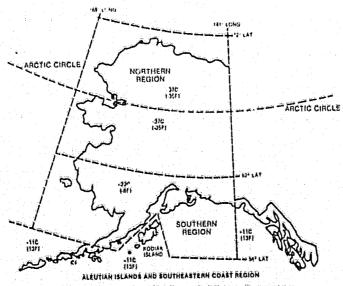


FIG. X2.8 November-10th l'ercentile Minimum Temperatures

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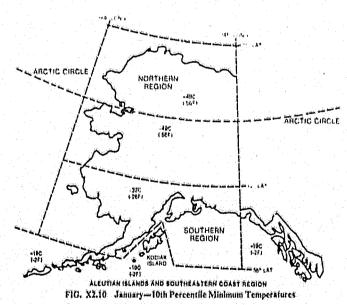
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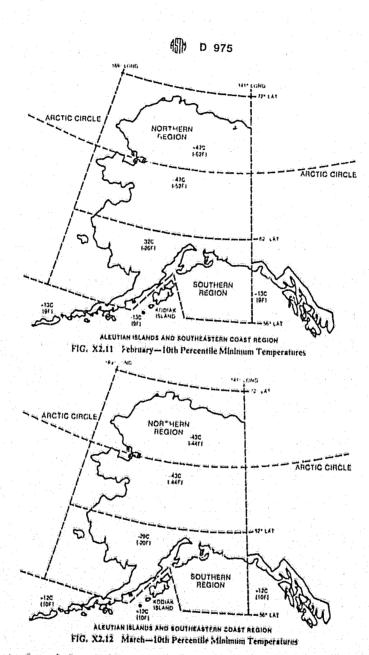
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FIG. X2.9 December-10th Percentile Minimum Temperatures



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British Standard Specification for

Fuel oils for oil engines and burners for non-marine use

Carburants pour moteurs et brûleurs à pétrole (usages non marins) - Spécifications

Dieselöle für Dieselmotoren und Ölbrenner außer für Verwendung in Schiffsdieselmaschinen

British Standards Institution

Contents Page Page Foreword Inside front cover Tables Committees responsible Back cover 3 1. Properties of engine fuels 2. Properties of burner fuels 4 3. Minimum storage and handling temperatures for Specification burner fuels of classes E, F, G and H 5 1. Scope 2. Sampling 3. Composition, properties and use of fuels 1 4. Precision and interpretation of test results 1. Symbol for class C1 burner fuel 5. Marking and labelling 2 Viscosity/temperature chart 3. Gross specific energy at constant volume (Q_{qq}) , Appendices in MJ/kg, of fuel oils for non-marine use 8 4. Net specific energy at constant pressure (Q_{np}) , A. Fuel types and applications 5 9 in MJ/kg, of fuel oils for non-marine use Storage and handling 5 C. Notes on properties 6

Foreword

This British Standard has been prepared under the direction of the Petroleum Standards Committee.

A British Standard BS 209 'Fuels for oil engines' was first published in 1924 and BS 742 'Oil fuels for burners' first appeared in 1937. Both these standards were subsequently revised and later combined, in 1957, into BS 2869 'Oil fuels'. A major revision of this standard took place in 1967 when the title was changed to 'Specification for petroleum fuels for oil engines and burners'. There was a partial revision in 1970 to include a new class of fuel (C1) for flueless domestic appliances at the request of the Home Office and subsequent substantive amendments were published. The present revision has been undertaken to incorporate these amendments and bring the standard up to date in further respects. It supersedes BS 2869: 1970 which is now withdrawn.

The Institute of Petroleum (IP) Godes place classes A and D fuels for inland use in their class III, with a minimum flash point of 56 °C and this limit has been adopted in this revision.

A separate British Standard, BS MA 100, for fuel oils for marine application and for marine engines for inland use has been prepared, based on discussions within the International Organization for Standardization (ISO) and therefore classes B1 and B2 have been deleted from this revision and are now specified as classes M2 and M3 respectively in BS MA 100 to which reference should be made for fuels for marine engines, even if used for inland applications. All references to marine applications have also been deleted.

The determination of cold filter plugging point has been substituted for the determination of cloud point for defining the low temperature characteristics of classes A1, A2 and D fuels. The new method is considered to provide a more realistic criterion in relation to use.

The desirability of including some specification to cover lubricity of classes A1 and A2 fuels has been raised during the preparation of this specification. However, in the absence of any established method to determine lubricity of these fuels reliably, this property cannot be included as a requirement.

It is recognized that there are some applications where, for technical or other reasons, limits different from those in

this standard or additional requirements may be necessary. This standard does not cover such special applications, which are matters for arrangement between the purchaser and the vendor.

The issue of an EEC Directive* relating to the sulphur content of gas oil necessitated, in 1977, amendments to the requirements for certain of the classes of fuel covered by the scope of this standard. The Directive refers to two types of gas oil, designated A and B, which are differentiated according to the intended areas of use. These designations are not equivalent to, and should not be confused with, the designations assigned to classes of fuel in this standard, which are differentiated on the basis of the limiting requirements given in table 1. Fuels complying with classes A1, A2 and D of this standard, however, could be subject to the provisions of this EEC Directive.

It will be noted that in the last 10 years more amendments to this standard have been needed than in any similar period previously. This was a consequence not only of more exacting requirements of fuel-using equipment and environmental legislation but also of a radically changed pattern of product demand. One or more of these factors is likely to require further changes to the standard before the next major revision. These will only be made if acceptable to all the various interests and organizations represented on the committee responsible for the standard and after the opportunity for public comment. Nevertheless, suppliers and users of oil fuels should be aware that changes may be needed to quality requirements and that these may be dictated primarily by the need to ensure adequate supply leyels.

The specifications given in this British Standard require the use of test methods standardized by the Institute of Fetroleum (IP) and the cooperation of this organization is gratefully acknowledged. By arrangement with the IP, many of these test methods have been issued as British Standards and cross-references between the British Standards and IP methods have been included. Most of these methods are published as Parts of BS 2000 and their Part numbers are identical with their IP Method numbers. These methods are to be used for referee purposes but the use of other methods for routine purposes is not precluded. Compliance with a British Standard does not of itself confer immunity from legal obligations.

^{*}Council Directive 175/716/EEC of the European Economic Community) on the approximation of the laws of Member States relating to the sulphur content of certain liquid fuels.

British Standard Specification for

Fuel oils for oil engines and burners for non-marine use

1. Scope

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This British Standard specifics properties for various classes of petroleum fuels for both oil engines and burners for non-marine use. The standard does not preclude the lawful use of one class of fuel in an appliance designed for use with a fuel of another class, except that it is strongly recommended that only class C1 burner fuel should be used in flueless domestic appliances, but points out the advisability of tests or consultation with the equipment manufacturer when fuel is to be used for a purpose other than that for which it is classified in the standard.

While this standard applies to petroleum fuels, it is recognized that there is currently growing interest in the possibility of deriving alternative fuels, e.g. from coal. When assessing the suitability of such alternative fuels, the standard may be used only as a general guide, since many of the criteria listed are of an empirical nature; their relevance to fuels of other than petroleum origin may therefore be questionable. For example, the equations referred to in C.2 and given in C.5 are unlikely to be valid for non-petroleum fuels.

Appendices A, B and C have been included for information only.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2. Sampling

2.1 Sampling from storage tanks. For the purposes of this British Standard, all sampling shall be carried out in accordance with the relevant sections of BS 3195: Part 1 and additionally as detailed in 2.2.

NOTE. The method described in 2.2 is designed for sampling the bulk of the fuel being fed to the offtake point. The examination of equipment (e.g. pumps) to detect faulty operation may require the use of different techniques.

2,2 Sampling from fuel lines

2.2.1 Sampling cans. Sampling cans shall be of 5 L capacity. NOTE. Attention is drawn to the fact that sampling cans will need to comply with the statutory safety requirements for the classification, packaging and labelling of dangerous substances, at present in course of preparation.

2.2.2 Preparation of cans. A stock of cans shall be kept solely for the purpose of taking fuel samples. Before use, all cans shall be checked to ensure they are sound and free from leaks. A fuel-resistant sealing washer in good condition shall be in position in the cap.

2.2.3 Procedure. From the offtake point, 5 L of the fuel to be tested shall be carefully drawn into a 5 L can using a clean dry funnel. The screw cap shall be fully tightened and

the can checked to ensure that there are no leaks.

NOTE. If more than 5 L are needed, the operation should be repeated immediately and before the pump has been used for any other purpose.

2.2.4 Labelling and transport. Full and legible information relating to the source of the sample shall be attached to the can in such a manner that it will not easily become detached subsequently.

NOTE 1. If required, the sample may be sealed and labelled to maintain its legal integrity.

NOTE 2. If the sample has to be sent to the laboratory by public transport, it will be necessary to comply with the general regulations covering transportation of flammable materials, where appropriate, and with the requirements of the transport authority concerned. Information on the appropriate procedures and type of packaging required should be obtained from the transport authority involved.

3. Composition, properties and use of fuels

NOTE. Recommendations relating to the application and use of these fuels are given in appendix ${\bf A}_{\star}$

3.1 The fuels shall be hydrocarbon oils derived from petroleum. This does not preclude the incorporation of small amounts of additives intended to improve some aspects of performance. The fuels shall be free from inorganic acid and from quantities of grit, fibrous material and other foreign matter likely to interfere with the operation of normal equipment.

NOTE 1. HM Customs and Excise require the statutory addition of prescribed dyes and/or markers to fuels used for certain purposes and also stipulate requirements in respect of other specification points. These additional requirements are not detailed here but do not conflict with the specification given below.

NOTE 2. The fuels may be dyed for the purposes of brand identification.

3.2 The petroleum fuels shall comply with the limiting requirements set out in tables 1 and 2 when tested by the methods indicated therein.

3.3 On visual inspection at ambient temperature, fuel oils complying with classes C1 and C2 shall be clear, bright and free from solid matter and undissolved water.

4. Precision and interpretation of test results

Most of the methods of test specified in tables 1 and 2 contain a statement of the precision, i.e. repeatability and reproducibility, to be expected from them but in cases of dispute the procedure described in BS 4306, which uses precision data in the interpretation of test results, shall be used.

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5. Marking and labelling

5.1 Class C1 burner fuel

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5.1.1 Symbol. The symbol for class C1 burner fuel shall be of the general form and proportions shown in figure 1. Its breadth shall not be less than 100 mm and its height shall not be less than 120 mm. Additional lettering or symbols shall neither be included within the outer rectangle nor closely associated with its perimeter. A space of not less than 10 mm shall be left between the perimeter of the symbol and any brand name or trade mark. The colour used for the design and lettering shall be in clear contrast to the background colour.

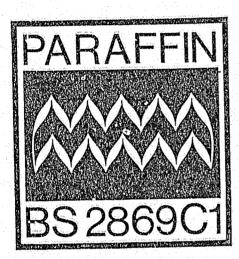


Figure 1. Symbol for class C1 burner fuel (reduced size)

5.1.2 Marking of pumps and containers. The following information shall be marked on each dispensing pump or container used for delivering class C1 burner fuel to the customer:

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(a) the vendor's name or mark;

(b) the symbol for class C1 burner fuel (see figure 1). The wording 'BS 2869: Class C1' or 'BS 2869: C1' shall not be used on pumps or containers unless the wording forms part of or is accompanied by the symbol (see 5.1.1).

5.1.3 Associated documents. If the symbol is used in documents relating to the sale and delivery of class C1 burner fuel or in advertising material, it shall retain the general form and proportions shown in figure 1.

NOTE 1. The breadth and height of the symbol may be decreased for use in documents, provided that the symbol remains recognizable and the lettering is legible.

Additional lettering or symbols shall neither be included within the outside rectangle nor closely associated with its perimeter. A space of not less than 5 mm or one-tenth of the breadth of the symbol, whichever is the greater, shall be left between the perimeter of the symbol and any brand name or trade mark.

NOTE 2. The wording 'BS 2869 : class C1' or 'BS 2869 : C1' may be used in documents relating to the sale and delivery of class C1 burner fuel without the symbol.

5.2 Class C2 burner fuel, Products supplied as complying with class C2 of this standard shall not be described as 'paraffin' or 'paraffin oil' in association with any reference to this standard.

NOTE. It is recommended that this fuel should be described as 'kerosine' in association with references to this standard.

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Table 1. Properties of engine fuels

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Property	Class A1	Class A2	Test method	
			British Standard	Technically equivalent institute of Petroleum standard
Viscosity, kinematic at 40 °C, cSt* min, max,	1,50 5.00	1,50 5,50	BS 2000 : Part 71	IP 71
Cetane number, min.	50 (see C,2)	45	BS 5580 f	†
Carbon residue, Ramsbottom on 10 % residue, % (m/m), max.	0.20	0,20	BS 4451	IP 14/65
Distillation, recovery at 350 °C, % (V/V), r. in.	85.0	85,0	BS 2000 : Part 123	IP 123
Flash point, closed, Pensky-Martens, °C, min.	56.0	56.0	BS 2000 : Part 34	1P 34
Water content, % (V/V), max.	0.05	0,05	BS 4385	IP 74/82
Sediment, % (m/m), max.	0,01	0.01	BS 4382	4
Ash, % (<i>m m</i>), max.	0.01	0.01	BS 4450 (EN 7)	
Sulphur content, % (m/m), max.	0.30§	0.50 §	BS 5379 (EN 41)	Mr. a
Copper corrosion test, mex.	1	Ť	BS 2000 : Part 154	IP 154
Cold filter plugging point (see C.4), °C, max. Summer (March/Sept. Inclusive)	Ö	Ö	BS 6188 (EN 116)	IP 309/80
Winter (October/Feb. Inclusive)	9	-9		

^{*1} cSt = 1 mm2/s.

1BS 5580 is identical with ISO 5165-1977 and makes reference to Method ASTM D813-65. Revisions of BS 5580: 1977 and ISO 5165-1977 are in course of preparation and will make reference to the edition of ASTM D613: IP 41 current at the time of publication of the revision of ISO 5165, Pending the publication of these revisions, tests for this requirement should be made using the method ASTM D613-82: IP 41/82,

#IP 53/82 superseded IP 53/70, which was technically equivalent to BS 4382, IP 53/70 only specified the expression of sediment as percentage by mass or percentage by volume but is otherwise still technically equivalent.

§This limit is set in accordance with the legislative requirements for gas-oil of the 'Council Directive (75/716/EEC of the European Economic Community) on the approximation of the laws of Member States relating to the sulphur content of certain liquid fuels' as embodied in Scatutory Instrument 1976 No. 1988 Public Health — The Motor Fuel (Sulphur Content of Gas Oil) Regulations 1976 and Statutory Instrument 1976 No. 1989 Public Health — The Oil Fuel (Sulphur Content of Gas Oil) Regulation 1976.

IIThe conditions of terrare to be as recommended for fuel oils in 7.1.1 of BS 2000 : Part 154 : 1982, test temperature to be 50 °C.

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Table 2. Properties of burner fuels

Property	Class C1	Class C2	Class D	Class E	Class F	Class G	Class H	Test method	
								British Standard	Technicall equivalent Institute o Petroleum standard
Viscosity, kinematic at 40 °C, cSt* min. max.	oine.	1.00 2,00	1.50 5.50	No. 14 - 14 to 14 to 15	and ,	,	مند	BS 2000 : Part 71	IP 71
Viscosity, kinematic at 80 °C, cSt*, max.	**************************************		ilian	13,50 (see C.1)	35,00 (see C.1)	85,0 (see C,1)	130.0 (see C.1)	8\$ 2000 ; Part 71	IP 71
Carbon residue, Ramsbottom on 10 % residue, % (m/m), max.		-	0.2					BS 4451	IP 14/65
Distillation recovery at 200 °C, % (V/V), min, recovery at 200 °C, % (V/V), max, recovery at 350 °C, % (V/V), min, final boiling point, ^b C, max.	15.0 60.0 280	15,0	 85.0	galan ukan		galan	prints	BS 2000 : Part 123	IP 123
Flesh point, closed, Abel, ⁶ C, min.	43.0	38.0	mile triangle review, rights, 22, 3, 5 ofer	su.			***	BS 2000 : Part 170	IP 170
Flash point, closed, Pensky- Martens, °C, min.	and	Vin	56.0	66.0	66.0	66.0	66,0	B\$ 2000 : Part 34	IP 34
Water content, % (V/V), max.	Sen 3.3	See 3.3	0.05	0,5	0.75	1.0	1.0	BS 4385	IP 74/82
Sediment, % (m/m), mex.	See 3.3	Sec 3.3	0.01	0.15	0,25	0.25	0,25	BS 4382	† ************************************
Ash, % (m/m), max.	_	**	0.01	0.15	0.15	0.20	0.20	BS 4450	###
Sulphur content, % (<i>m/m</i>), max.	0.04	0.20	0.50+	3.50	3,50	4.00	4,00	BS 2000: Part 107 BS 5379 (EN 41) BS 2000: Part 61	IP 107
Copper corrosion test, max.	1	1	7			===		B\$ 2000 : Part 154 §	IP 154
Cold filter plugging point, °C, max. Summer (Merch/Sept. Inclusive) Winter (October/Feb. Inclusive)		No.	o _g	***	p			BS 6188 (EN 116)	IP 309/80
Smake point, mm, min.	35	20	<u> </u>	dryenikajan ya (m du.,	44		<u> </u>	BS 2000 : Part 57	IP 57
Char value, mg/kg, max,	10	20	Enc.	plane		شو	Book	BS 2000 : Part 10	IP 10

^{*1} cSt = 1 mm¹/s

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t1P 53/82 superseded IP 53/70 which was technically equivalent to BS 4382. IP 53/70 only specified the expression of sediment as percentage by mass or percentage by volume but is otherwise still technically equivalent.

⁺This limit is set in accordance with the legislative requirements for gas-oil of the 'Council Directive (75/716/EEC of the European Economic Community) on the approximation of the laws of the Member States relating to the sulphur content of certain liquid fuels' as embodied in Statutory Instrument 1976 No. 1988.

^{\$}The conditions of test are to be as recommended for fuel oils in 7.1.1 of 85 2000 : Part 154 : 1982, test temperature to be 50 °C.

Appendix A

Fuel types and applications

A.1 General. The fuel used in an appliance should be as recommended by the equipment manufacturer. However, it is recognized that many types of oil-consuming appliances which normally use a particular class of fuel can, in certain circumstances, consume quite satisfactorily a fuel falling within the limits of another class. A typical case is the widespread use of burner fuels for the larger oil engines. If a fuel is to be used for a purpose other than that for which it is classified in this standard, the user should satisfy himself by test or consultation with the equipment manufacturer that it can be used satisfactorily in his appliance.

A.2 Engine fuels

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A.2.1 The two classes of fuel specified in table 1 are marketed specifically as oil engine fuels. Class A1 is of higher quality and is intended primarily as an automotive diesel fuel, whilst class A2 is intended as a general purpose diesel fuel. Classes A1 and A2 are distillate grades and are so specified as to prevent the inclusion of residuum.

A.2.2 The specifications for classes A: and A2 include limits for cold filter plugging point chosen to cover seasonal requirements in the UK (see C.4).

A.2.3 Ignition quality is specified in terms of cetane number but the calculated cetane index is referred to as an alternative for routine purposes with fuels not containing ignition improver additives (see C.2).

A.2.4 The gross and net specific energy of engine fuels may be calculated from equations given in C.5.

A.3 Burner fuels

A.3.1 Of the seven classes of fuel for oil burners specified in table 2, classes C1 and C2 cover distillate fuels of the kerosine type; class C1 being for flueless domestic heating appliances and class C2 for vaporizing and atomizing burners, mainly used for domestic heating in appliances connected to flues. Class D is a distillate grade for atomizing burners in domestic and industrial use and its specification includes a cold filter plugging point limit which indicates that it can be stored and used at normal ambient temperatures (see C.4). Classes C1 and C2 can be stored and used at any ambient temperature likely to be encountered in the UK.

A.3.2 Classes E to H are residual or blended fuels and normally require preheating before combustion. The standard temperature for the determination of the viscosity of these fuels is 80 °C which ensures more consistent test results.

A.3.3 The gross and net specific energies of burner fuels may be calculated from equations given in C.5.

A.3.4 Burner fuels of classes E to G are used in certain types of oil engines. They are not sold, however, with any guarantee of suitability for this purpose and intending users should satisfy themselves by test or consultation with the engine manufacturer that any particular fuel will be suitable for their equipment, e.g. attention may need to be paid to the proportion of ash-forming constituents present.

Appendix B

Storage and handling

B.1 Fuels of classes A1, A2 and D. Guidance on the cold weather use of these fuels is given in BS 6380. Exposure of these fuels to temperatures significantly below -9 °C for long periods may cause restriction to flow. Problems may also be experienced if summer grade material with a higher cold filter plugging point (see C,4) is still present in significant amounts in the fuel used during the winter period. Where continuity of operation is essential and/or in locations known to suffer severe cold spells, it is advisable to take adequate precautions beforehand.

For installations in which class D fuels are in use, lagging the storage tank and associated pipework and fittings is useful. In addition, it may be necessary to install heating equipment to provide a minimum storage and handling temperature between 0 °C and 5 °C in accordance with BS 5410: Parts 1, 2 and 3.

In storage installations and vehicles using classes A1 and A2 fuels, precautions are also necessary. The British Technical Council of the Motor and Petroleum Industries* has also made suitable recommendations for fuel storage systems, the design and service of low pressure fuel systems of vehicles, and recommendations for low temperature operation of diesel vehicles, including remedial measures in cases of fuel starvation by wax.

B.2 Fuels of classes E, F, G and H. Fuels of classes E to H require storage and handling plant equipped with heating facilities. The minimum temperatures which may be expected to give satisfactory results with all fuels of the given class are given in table 3.

Users should satisfy themselves that their storage and handling plant is adequately equipped to maintain the fuel at, or just above, the appropriate temperature given in the table. Heating facilities should be designed in accordance with BS 799: Parts 4 and 5 and BS 5410: Parts 2 and 3.

Table 3, Minimum storage and handling temperatures for burner fuels of classes E, F, G and H

Class of fuel	Minimum temperature for storage	Minimum temperature for outflow from storage and for handling
**************	°C	°C
E	10	10
#	25	30
G	40	50
Н	45	55

While the minimum temperatures quoted in table 3 ensure satisfactory results with all fuels of a given class, it is well known that many fuels will flow satisfactorily at lower temperatures. In the interests of energy conservation, consumers may wish to determine the minimum temperature for satisfactory flow of the fuel. The pumpability test method for industrial fuel oils (BS 2000 : Part 230, identical with IP 230) can be used in such cases as a guide to the minimum safe storage and handling temperatures of fuel oils. If working below the minimum temperature shown above, it may be necessary to test each delivery of fuel oil, particularly if fuels are received from more than one source.

^{*&#}x27;Diesel Fuel Systems for Low Temperature Operations', August 1979, available from the British Technical Council of the Motor and Petroleum Industries, Secretarial Offices, MIRA, Watling Street, Nuneston, Warwickshire.

Appendix C

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Notes on properties

C.1 Viscosity/temperature relationship. The four lines drawn on the chart in figure 2 show average viscosity/temperature relationships for fuels of classes E to H at the maximum viscosity specified in this standard. The approximate viscosity/temperature relationship for any petroleum oil fuel within these classes, for which the viscosity at one temperature is known, can be determined by drawing through the known viscosity/temperature intersection a line parallel to those shown. From this line can be read the approximate temperature required for any desired viscosity, e.g. that specified by burner makers for proper atomization.

In the regions indicated by broken lines on the graph, the viscosity/temperature relationship cannot be adequately defined for all fuels. Guidance on viscosities at low temperatures should be sought from the fuel oil supplier.

C.2 Cetane index. The calculated cetane index is approximately equivalent to the determined cetane number for fuels that do not contain additives to improve the ignition quality. This index may be used as an alternative to cetane number for quality control purposes.

The equation for the calculated cetane index is given in BS 2000; Part 218 (identical with IP 218), but for easy reference BS 2000; Part 218 includes a nomograph (see A 2.3)

C.3 Density. Density, whilst it may be controlled during production, is not specified. It is necessary to know the density for converting bulk volume to mass, as well as for calculating the cerane index (see C.2) and specific energy (see C.5). Density may be quoted by the oil supplier or otherwise may be determined by the methods described in BS 4714 or BS 5093, which are technically equivalent to IP 160 and IP 190, respectively.

C.4 Gold filter plugging point. Cold filter plugging point has now been adopted as a standard test method in many European countries as it represents the most realistic method of assessing the low temperature flow properties of gas oils such as classes A1, A2 and D in this standard.

The winter limit of -9 °C in this standard was specified following consideration of hourly, 4 hourly and 8 hourly temperature data recorded over the 30 years 1949 to 1978

at a pair of Meteorological Office Stations among those consistently reporting the coldest extremes of air temperature for a populous area in the United Kingdom. The two stations considered were located close to each other and by combining their records one continuous set of data for 30 years was obtained. At these sites temperatures of -8 °C and below were found to occur for periods of 4 h duration or longer on only 15 occasions and for periods of 8 h duration or longer on only 7 occasions during the entire 30 year period. This was considered to be an acceptable degree of risk, being frequencies of 1 in 300 and 1 in 650 respectively for the 5 months during which the winter grade is specified.

Whilst there is no fixed relationship between the cloud point and cold filter plugging point of a fuel, the differential will rarely exceed 13 °C.

C.5 Specific energy, Specific energy (calorific value) is not controlled in the manufacture of fuel except in a secondary manner by the specification of other properties. Gross specific energy at constant volume $(Q_{\rm gy})$ can be determined by the method described in BS 2000: Part 12 (technically equivalent to IP 12) which includes the method for obtaining the net specific energy at constant pressure $(Q_{\rm np})$.

Specific energy (in MJ/kg) can be calculated with a degree of accuracy acceptable for normal purposes from the density of a fuel, applying corrections for any sulphur, water and incombustibles (ash) that may be present as follows:

$$Q_{gv} = (51.916 - 8.792p^2)(1 - (x + y + s)) + 9.420s$$

 $Q_{np} = (46.423 - 8.792p^2 + 3.170p)(1 - (x + y + s)) + + 9.420s - 2.449x$

where

p is the density at 15 °C (g/mL);

x is the proportion by mass of water (% divided by 100;

y is the proportion by mass of ash (% divided by 100);

s is the proportion by mass of sulphur (% divided by 100).

For rapid estimation, values may be read from figures 3 and 4 which have been derived from the above equations.

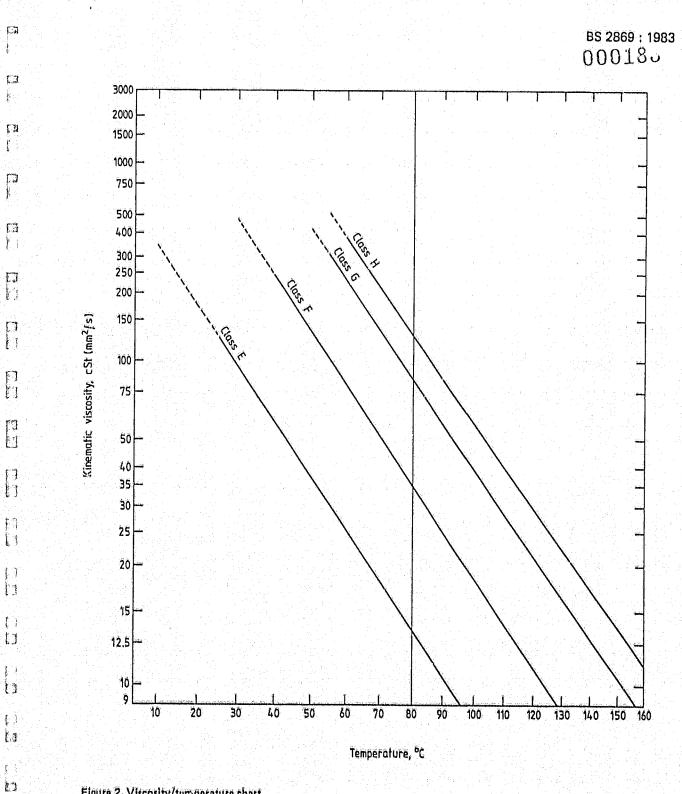


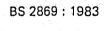
Figure 2. Viscosity/tumperature chart

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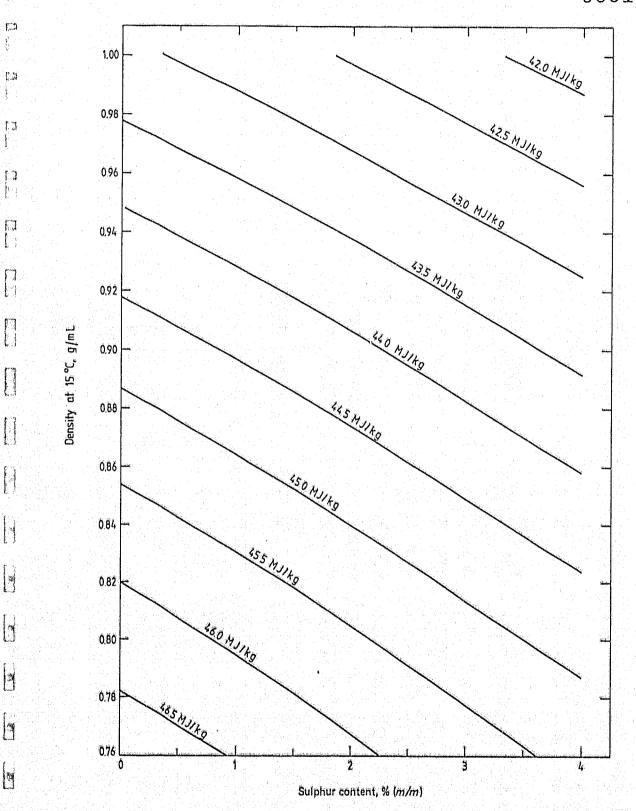
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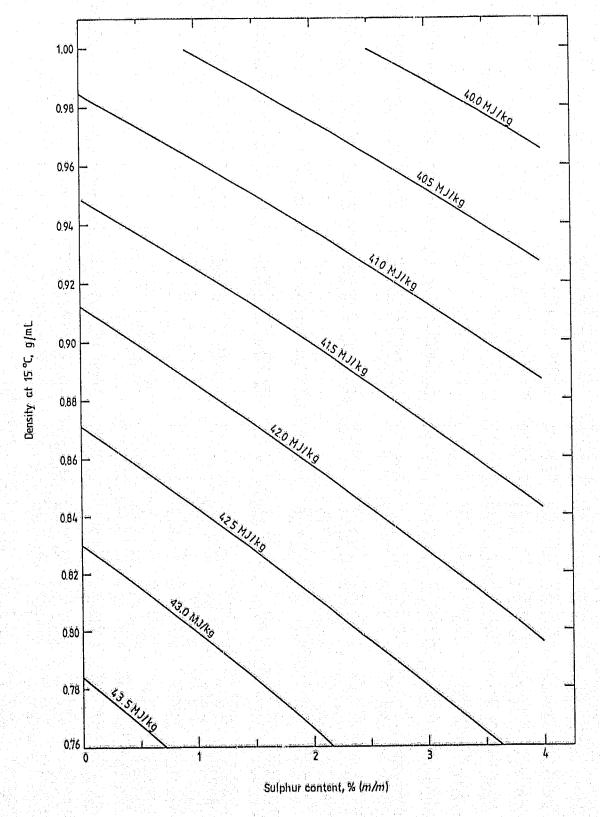
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NOTE. To correct for ash and water subtract 0.01 $\sigma_{\rm gv}$ (% ash + % water) from gross specific energy at constant volume ($\sigma_{\rm gv}$) read from this graph.

Figure 3. Gross specific energy at constant volume (Q_{q_0}), in MJ/kg, of fuel oils for non-marine use



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NOTE. To correct for ash and water subtract 0.010_{np} (% ash + % water) from net specific energy at constant pressure (0_{np}) read from this graph.

Figure 4. Net specific energy at constant pressure (a_{np}) , in MJ/kg, of fuel oils for non-marine use

Automotive diesel fuel storage and handling

To obtain satisfactory performance from diesel engines, operators need to know how to handle the fuel (to make sure it remains in good condition, free from dirt and water contamination) and how to avoid problems from solidified wax if the fuel is cooled below critical temperatures.

How to get the best results from diesel fuel High-speed diesel engines, as used in tractors, trucks and motor cars, operate on automotive diesel fuel (ADF) which is also known as automotive distillate, automotive diesel oil (ADO) or diesel distillate as well as by several proprietary brand names, such as Diesoline and Diesoleum. For clarity, the single term diesel fuel is used in this publication to cover all these.

Diesel fuel is manufactured to specifications that ensure trouble-free use in most applications, most of the time. For many years, user problems were few. Production quality in Australia had been well within specification limits, allowing a range of tolerance. Recently, however, production quality has more nearly approached the specification limits, so there is more likelihood of problems arising in marginal or exceptional applications.

The changes have been made because the use of diesel fuel is

The changes have been made because the use of diesel fuel is growing more rapidly than that of other fuels; it is in the national interest, as well as being Government policy, to extract as much fuel as possible from the waxy, indigenous Bass Strait crude oil. For these reasons, there is unlikely to be any significant further change in fuel quality, and users should minimise operational problems by adopting recommendations set out in this data sheet.

tech data 15



Summary: Diesel fuel handling

Store fuel properly

- Store fuel in bare steel tanks or containers avoid galvanised
- Store fuel in bare steel tanks or containers ayout gaivanised from and copper.
 Where possible, protect the storage 'ank from the sun in summer.
 Drain sediment and condensed water from tanks before each delivery and especially at onset of winter.
 Diesel fuel should last at least 12 months, but turn stock over by almost emptying before refilling.
 Don't carry over summer grade fuel for use in winter.

Look after drums

- To exclude moisture, store drums off the ground and on their sides, with bungs at 3 and 9 o'clock positions.

 Keep drums in the shade where possible.

 Use them in rotation first in, first out.

 Minimise carry-over of summer grade fuel for use in winter.

Some tractor tips

- Drain sediment from running tank regularly.
 Refill tank after use, to exclude moisture.
 Service the fuel filter elements regularly.
 Change to winter grade crankcase oil before winter.

Cold weather operating procedures

- Winterise machines prior to onset of cold weather.
 Protect equipment from the elements overnight,
 Insulate fuel lines, filter and running tank,
 In the event of fuel starvation by waxing;
 Remove or change the filter element
 Warm the fuel system to dissolve wax and melt ice
 Use from 25 per cent to 50 per cent heating oil mixed into dlesel fuel to reduce wax
 For frost and snow conditions, check dipstick. If lubricating oil is frozen, don't start!

The storage and handling of automotive diesel fuel

Fuel storage

Diesel fuel tanks may be installed above ground, on the ground, or underground.
Aboveground tanks are

Aboveground tanks are relatively cheap to install, are easily moved, and allow gravity flow whon fuelling vehicles, but they are exposed to the hot am which can reduce the life of the fuel by dearfuller.

ure exposed to the hot am which can reduce the life of the fuel by degradation.

On-the-ground tanks on low supports are the cheapest to install, but require pumps for fuelling vehicles, and the fuel is subject to the heat of the sun unless cover is provided.

Underground tanks are the most expensive to install and also require pumps for fuelling vehicles, but the fuel is kept at an even temperature and will last for longer periods without deteriorating, However, removal of water and sediment is more difficult.

For safety reasons, diesel fuel is the fuel is the fuel.

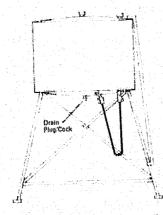
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difficult.

For safety reasons, diesel fuel tanks should be located at least 7.5 metres from buildings for aboveground or on-the-ground tanks and at least 3 metres from buildings in the case of underground tanks.

Aboveground tanks.

Aboveground tanks should have 15 mm to 20 mm drain cocks or valves at their lowest points to allow drainage of sediment and water. These are preferable to drain plugs which allow no control of flow, and are



risky to use with the tank full. The main fuel outlet should be fitted with a valve, filter, pump

(if required), hose and a trigger nozzle, while the entry to the outlet pipe should be 50 mm above the bottom of the tank to avoid picking up water or sedi-ment.

Underground tanks should have a hand pump permanently connected to a drainage sump.

Materials of construction

Tanks and drums should be filled to leave sufficient ullage (at least 3 per cent of total volume) to allow for fuel expansion with a rise in temperature. All tanks should be vented to the atmosphere and to prevent pressure build-up and to allow air to enter as fuel is with-

drawn, Drums are sealed, and drawn. Drums are search, and are strong enough to withstand the pressure, provided there is 3 per cent ullage, Plain steel containers provide the usual method of storing fuel (whether in drums, vehicle running tanks or bulk

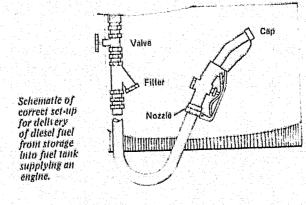
vehicle running tanks or blik storage).

Galvanised steel drums or tanks are NOT recommended for storage because the zine causes product oxidation and gum formation which can block filters and injectors. The galvanising releases a fine powder of zine oxide which can pass through filters to form deposits in the induction and combustion systems

onac where can pass in the induction and combustion systems of piston engines. It can also cause unpleasant odours from small quantities of sulphur compounds in the fuel.

Copper should NOT be used for storing fuel as it promotes catalytic action to form deposits of gum, if copper tanks are used, they should be treated internally with an oil-resistant coating, and copper fuel lines should be tinned. Sieel lines are preferable (or perhaps nylon in cases where no fire hazard exists). Plastic containers should NOT be used for storing petroleum

be used for storing petroleum products unless they are speci-fically intended for the purpose. Plastics can deteriorate at even moderate temperatures, increasing the danger of leakage or spillage.



Although lubricating oils are often sold in acceptable plastic containers, other petroleum products can penetrate unsuitable plastics or weep through cracks or screw tops. Ultraviolet light from the sun accelerates cracking of most plastics.

of most plastics.

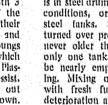
Concrete tanks may be used for fuel storage, particularly if the concrete is dense and the tanks are well constructed, but the concrete may be slightly porous, allowing seepage at construction joints. Fine powder may be produced from the surface of the concrete, causing filter blockage or deposits. However, concrete is a feasible storage tank material.

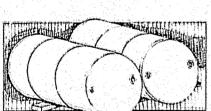
Drum storage

Care should be used, in storing and handling drums, to keep out dirt and moisture. Store under cover where possible. it is best to keep drums at a uniform temperature as variations

uniform temperature as variations in temperature can draw moisture into the drums.

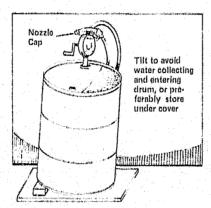
Drums, if stored outside, should be off the ground and on their sides with bungs at both 3 and 9 o'clock positions. If the drums cannot be laid on their sides, tilt them slightly and turn the drum so that the bungs are given from any water which are away from any water which collects. Keep bungs tight. Plastic covers over drums can assist.
Cover the funnels to keep out
dirt, or store them upside down.
Drums of fuel should be used in
rotation—first in, first out,





Correct method for storing drums on their sides. Note the position of bungs at the 3 and 9 o'clock positions.

Use of drums



Correct arrangement for a diesel fuel drum from which fuel is to be extracted. The bungs are at the 3 and 9 o'clock positions, and the drum is tilted to keep any water away from

Storage life

The nominal storage life of diesel fuel may be taken as 12 months, which normally allows an adequate safety margin before deterioration.

There are many factors which affect the storage life of fuel. The preferred method of storage is in translationary and the storage life of fuel.

The preferred method of storage is in steel drums in cool or shaded conditions, or in underground steel fanks. Stock should be turned over progressively so it is never older than 12 months. If only one tank is used, it should be nearly emptled before refilling. Mixing old degraded fuel with fresh fuel can accelerate deterioration and shorten the life of the new fuel.

Slightly different grades of

diesel fuel are manufactured by refineries at different times of the year to cater for seasonal tem-perature variations, if cold-flow properties are important, care should be taken not to mix summer grade with winter grade

Shading from direct sunlight can reduce gum and varnish-forming tendencies in an above-ground tank or in drums. This ground tank or in drums. This will also minimise "breathing" and help to keep moisture from condensing in the tank. Fuef may contain a gum inhibitor added by the refiner to retard the formation of gum and varnish. However, it may still be affected eventually by oxidation and gum deposits will develop which will upset fuel systems and engines.

engines.
Colour at the time of manu-Colour at the time of manufacture is not necessarily a guide to diesel fuel quality. However, many petroleum products undergo colour change in an open container, particularly if exposed to the ultraviolet rays of sunlight.

Use of degraded fuels

When fuel has become significantly off-colour, or develops an unpleasant odour or sludge deposits during long-term storage, it should not normally be used for internal combustion engines unless it has been pre-filtered through a nominal 3 micron filter. 3

nominal 3 micron filter,
I'tels which have undergone
mild to moderate degradation
may often be used in a normal
way, depending on the luci system sensitivity. Filters and other
clean-up equipment may require
special attention and increased
maintenance, injector fouling may

occur more rapidly than normal.
Fuels containing very large
quantities of fuel degradation proquantities of fuel degradation products or other contaminants, or which have runaway microbiological growth, require special attention. Consultation with the suppliers is desirable. It may be possible to drain and discard the sediment, or draw off most of the fuel above the sediment layer and use it with care. However, very high levels of soluble gum or corrosion products from microbiological contamination may biological contamination may cause severe operational problems.

Maintaining fuel quality

These days, because of rising prices or product shortages, larger stocks of diesel fuel are often held by users. Proper management of these stocks is vital if product life and quality are not to be affected adversely.

While diesel fuel should remain in good condition for at least 12 months, it is affected by storage conditions such as high temperature and the presence of water or sludge. Ultimately fuel can become off-colour, develop an unpleasant odour, or deposit sludge at the bottom of the tank.

Tanks "breathe" with tempera-

ture changes, and air is drawn in when product is removed. When moist air above the fuel is chilled, moist air above the fuel is chilled, as on cold nights, dew is formed within the tanks and collects in the tank bottom. The water/fuel interface is a fertile site for bacteria which can give rise to sludge formation or sulphurous smells.

Dirt and water

All fuels must be kept free of dirt and water, but this is especially important with diesel fuel cially important with diesel fuel because the injection system on a diesel engine is manufactured with minute clearances. Very fine dirt particles soon ruin components and load to expensive repairs. Water, even in extremely small amounts, causes corrosion of the highly-trollend surfaces of fuel the highly-polished surfaces of fuel pumps and injector nozzles. Diesel operation manuals emphasise the importance of clean fuel.

Water in diesel fuel settles out

relatively slowly. For this reason, allow 24 hours for water and dirt allow 24 hours for water and dirt to settle to the bottom of the storage tank after it has been refilled. Use of two storage tanks allows the contents of one to settle while the other is in use, if there is only one storage tank, fill running tanks before disturbing the storage tank with a new fuel delivery.

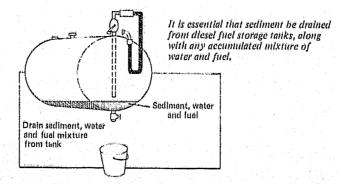
Allow drums to settle before numning from them.

pumping from them.

Draining the tanks

Regular drainage of condensed water and sediment from the tank water and sediment from the tank bottom is essential. This should be done several times a year, pre-ferably just before the tank is refilled. The tank should be drained in autumn to make way for winter-grade fuels, or when it has been sitting unused for some time

Internal deposits are out of sight and very often out of mind. Inspections of farm storage tanks



show that often they are not show that often they are not drained of condensation and degradation products, and these inevitably accumulate. With longer storage periods, it is essential to make a special effort to drain off this contaminated material, which accelerates the degradation of footh first and mark disease. of fresh fuel and upsets diesel operation by filter blockage or

operation by filter blockage or damage to injectors.
Additives may be introduced by refiners to prolong fuel's storage life and minimise de-posits. Despite the improvement, the need for regular drainage of moisture and sediment remains.

Sometimes it is necessary to flush out the tank to remove accumulated sediment and water, and the contaminated fuel may be kept in a container for 24 hours to allow dirt and w to settle, if it settles adequately, the clean portion of the fuel can be returned carefully to the clean storage tank.

Running tanks on tractors and other vehicles such as trucks should be drained several times a year by means of the drain plug, followed by flushing out

vessels should be cleaned of water and sediment at regular intervals. The entire contents of the tank should be drained or pumped out and a small charge of clean fuel used to flush out any particles and condensation products left in

In the past, the need for regular drainage has not been sufficiently emphasised, and users are unawate of the need to drain tanks on a regular basis. Following these recommendations would help to ensure trouble-free service with diesel engines and fuel.

Characteristics at low temperatures

Diesel fuels are complex mixtures of many components, including traces of wax. (See next section, Cold Weather Operations.) section, Cold Weather Operations.)
At very low temperatures, small wax crystals will start to form in the oil. They can coagulate and eventually block fine filters, obstructing fuel flow.

The temperature at which wax crystals start to be visible in cooling diesel fuel is termed the cloud point, If the fuel is fur-

ther cooled, more waxes come out of solution and form a structure which ultimately makes the fuel unpourable. The lowest temperature at which the fuel re-mains pourable (in a standard laboratory test) is known as the

pour point.
Neither of these temperatures gives a precise indication of the operational limits of diesel fuel. In most instances, the cloud point test gives too pessimistic an indication of the lowest temperature at which a fuel can perform satisfactorily, while the pour point gives an overly opti-mistic estimate. But cloud point is the safer indicator.

Summer and Winter grades

Seasonal grades of diesel fuel are distributed at appropriate times during the year. These are summer and winter grades, and, summer and winter grades, and, sometimes, an intermediate grade. The winter grade cloud point in southern and eastern Australia is normally around -1°C or -2°C, while that for summer grade is around 5°C. These depend on the supplier, the refinery, the crude oil and the geographic location. The pour point is usually about 3°C lower than the cloud point. point.
As the summer grade has a

As the summer grade has a higher cloud point (the temperature at which wax precipitation starts to occur) than the whiter g...de, problems can occur when stocks of summer grade held by users are used in winter months. The new seasonal grades take some time to work through the storage and distribution system. Winter grades are normally intro-Winter grades are normally intro-duced a few months prior to the start of winter so they are avail-able in the field at the right

Users storing fuel over a period may have a blend of grades, de-

pending on when they were pur-chased, and mixtures of summer, winter and intermediate grades commonly occur. Awareness of scasonal grades is necessary for those operating in colder regions. Grade differentation by colouring has been suggested but is impracticable because the colour of new fuel varies from clear to dark brown and it is not possible to obtain a uniform product colour

by dyelng.

Users with potentially cold operating conditions must be conscious of the time of year that fuel is delivered, and the resulting seasonal grade. They should also these these with that remarks also check with their supplier.

Cold weather operation

Bass Strait crude oil differs from Middle East crudes in that it contains a high proportion of wax which, because of its characteristics, cannot effectively be neutralised by additives. Wax is an excellent component for combustion quality, but when the temperature is too low it can solidify, blocking lines and filters.

In Australia, although winter temperatures in the colder regions are generally not as severe as in many other parts of the world, some problems can arise from low-temperature thickening of diesel fuels due to wax formation. Precautions should be taken by diesel equipment operators to prevent fuel in storage tanks and in engine fuel systems from falling below the critical tem-

in engine fuel systems from falling below the critical temperature.

If practicable, vehicles should be garaged overnight; otherwise they should be so parked as to minimise frost. If possible, cover the engine and fuel system with transport by the part for the country f a tarpaulin but do not forget to remove it before start-up. Water-proof lagging of exposed tanks and lines would be helpful.

Ideally, storage tanks should be underground if low temperature conditions are common, Pipework should be insulated and installed without sharp bends or strictions to flow.

Ice formation

Free water in fuel can freeze and ice crystals can plug fitel filters, causing fuel starvation. Care should be taken to keep fuel storage tanks free of water by regular drain checks.

Free water in vehicle fuel tanks can come from storage tanks, from condensation or from dissolved water, Condensation oc-curs when the air in the fuel tank curs when the air in the fuel tank cools down during a shutdown period; this can be avoided by topping-off fuel tanks before shutdown to reduce the volume of the air space above the fuel. If free water in fuel is a persistent problem even in warm tent problem even in warm weather, consideration might be given to installing a fuel/water separator.

Equipment preparation

It is a wise precaution to "winterise" tractors and other diesel-powered equipment before winter starts. Operators should follow the maintenance recommendations from the equipment mendations from the equipment manufacturer, making sure to use the correct crankease oil and cooling system anti-freeze. Fuel filters should be serviced regu-larly in accordance with equip-ment manufacturer's instructions. It is essential to make a special effort to drain away tank bottom accumulations.
Without inhibitors, water will

rust, corrode and leave deposits in the engine. Without an anti-freeze solution, it will freeze at 0°C. The safest rule is to add inhibitors to the radiator water even in summer to prevent rust,

and deposits. Most corrosion corrosion and deposits. Most antifreeze solutions have these inhibitors, while, for summer operation, various inhibitor compounds or conditioners are available.

Crankcase lubrication

Lubricants for diesel engines do not in themselves have a wax content problem and those re-commended by the engine manufacturer for winter operation will perform well in any degree of cold likely to be encountered. However, problems can arise if crankcase lubricants are excessively contaminated by diesel fuel sively contaminated by diesel fuel containing wax, through a process known as fuel dilution. Some unburned fuel will pass the piston rings during normal operation, and if the cylinder and rings are in poor condition, the amount of this dilution increases. Dribbling injectors or excessive fuelling will increase the amount of fuel increase the amount of fuel

passing the rings.

The wax transferred with the fuel can reduce the ability of the crankease lubricant to flow during occur in the short but critical warm-up period in an engine starved of normal lubrication.

To minimise dilution of crank-

case oil, the following steps should be taken:

Change the engine oil at

Change the engine oil at intervals recommended for the prevailing conditions, and more frequently in the case of old equipment in poor condition.

Change the engine oil at the onset of winter, using the winter grade recommended by the engine manufacturer.

Avoid prolonged idling which gives poorer fuel consumption

and aggravates the problem. Maintain fuel systems by following the manufacturer's re-commendations. Check the condition of fuel injectors and pump and any restriction to the air filter, such as a dirty element.

Special note on crankcase lubrication

Always examine the crankcase oil dip stick BEFORE STARTING. If the oil is NOT in a fluid condition, THE ENGINE SHOULD NOT BE STARTED until the condition has been rectified. Failure to do this can bring disaster.

Fuel additives

There are various fuel additives designed to reduce the pour point. They are commonly referred to as pour point depressant additives, cold flow improver additives, wax crystal modifications. flers, or fluidity improver addi-tives. These additives do not retires. These additives do not reduce the cloud point, but they can reduce the pour point of some fuels. Unfortunately, none of the existing additives are effective in diesel fuels made from Bass Strait crude oil. Normally, as fuel cools slowly, the wax forms large crystals, but mally, as hiel cools slowly, the wax forms large crystals, but the pour point depressant additives where effective, limit crystal growth. These smaller crystals allow pumping of the fuel at lower temperatures in non-filtered systems, but they may still block the normal fine fuel

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Thus pour point depressants are not really effective in reducing wax crystal size sufficiently for them to pass through diesel fuel filters. Work is continuing on trakes to develop tinuing on trying to develop additives which might achieve sufficient crystal size reduction to reduce filter blocking, but success is by no means assured, particularly with Bass Strait fuels.

Blending with heating oil

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In areas of low ambient temperatures with frost or snow conditions, was separation from diesel fuel may clog filters, resulting in fuel starvation. Heating oil has a much lower wax content than normal distillate, and tent than normal distillate, and low-temperature operating problems may be significantly reduced by the addition of heating oil to diesel fuel where permitted by the engine manufacturer. The cloud point of heating oil is around -25°C. A small cost penalty of several cents per litre may be involved. invalved.

involved.

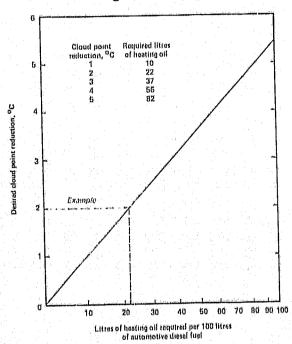
An effective solution is to blend 25 per cent to 50 per cent of heating oil with diesel fuel (i.e., 1:3 to 1:1 mixtures) which can depress the cloud point (when wax starts to form) by approximately 2.5°C to 5°C respectively. The attached graph indicates the quantity of heating oil required per 100 litres of typical diesel fuel to reduce the cloud point by a desired amount. (On the graph, 22 litres of heating oil added to 100 litres of diesel fuel will reduce the cloud point by 2°C.)

This retains normal standards

This retains normal standards for viscosity, boiling range and cetane number and should not affect engine warranties. (Cetane number is the diesel fuel equivalent of actana number for patents.) number is the diesel fuel equivalent of octane number for petrol.)
Heating oil itself is a very good
diesel fuel, it has a cetane number
equivalent to that of diesel fuel
and will present no combustion
problem. Its effect on overall
fuel quality is confined to cloud
and pour points, viscosity and
boiling range.

If too much heating oil is
added, the viscosity of the fuel is
greatly reduced, leading to possible fuel pump and injector wear
through reduced lubricative properties when used for extended

Heating oil blending chart



point products, and it may also point products, and it may also reduce the viscosity unacceptably. Petrol should NEVER be blended with diesel fuel. Petrol blending creates a serious safety problem because of petrol's very low flash point. Petrol also reduces the viscosity of the fuel dramatically and can lead to fuel system duninge due to insufficient lubrication. Petrol does not reduce cloud and pour points significantly and therefore is not an effective blending agent. effective blending agent.

Guide on excise duty on heating oil

NOTE: The Ihreau of Customs, Canberra, has advised that heating oil, when mixed with diesel fuel, becomes an excisable fuel which should be obtained in the blended state from oil company suppliers.

periods. In very cold weather this is an unlikely occurrence, but it is the reason why no more than a 50:50 mixture of heating oil and diesel fuel should be used.

In summary, there is no technical objection to mixing up to 50 per cent of heating oil with ordinary diesel fuel, although 25 per cent normally should be sufficient. Such a fuel will operate a diesel engine as satisfactorily as straight diesel fuel, and normally will meet all the requirements of diesel engine manufacturers. If in doubt, check with the manufacturer's agent.

It may be possible to fit a small auxiliary tank in which a blend of up to 50 per cent of heating oil with diesel fuel is stored. Switching from the main fuel tank to the auxiliary fuel tank five minutes before engine shutdown will prime the fuel system with this fuel and assist with cold engine start-up. Return lines and valving would have to be provided to return to the auxiliary or main tank.

Note that lighting kerosine should NOT be used in lieu of should NOT be used in lieu of flash point may create hazards in systems designed for high flash

See next page for information on emergency procedures for cold start-up and other Information about operation in very cold weather :-

Emergency procedures for cold start-up

- Check dinstick. If the le' ricating oll is frozen, do not attempt to start engine.
- If fuel starvation occurs, the following actions should be tried to re-establish fuel flow:
 - Ensure that ice is not
 - the cause. Remove filter elements and clear fuel lines. Often this is all the corrective
 - nction necessary.
 If possible, start the engine and run until warm. There will then be suffi-cient heat to prevent further blockage and new filter elements should then be installed, idling with the cooling air flow restricted can be benefi-
 - cial.

 If these methods do not succeed, remove filter elements and pour hot

water over the filter body and pipe work, taking care not to get water into the fuel system. Heat sources such as a steam cleaner or a hot air blower may be used. If another vehicle is avail-

- able with its engine run-ning, a heat-resistant hose can be used to direct exhaust gases on to the blocked lines, taking care that the operator does not inhale exhaust fumes.
- NEVER light fires under vehicle tanks. (People have tried it disas-
- where practicable, refill the fuel system (after drainage) with the correct seasonal grade of fuel or n heating oil/diesel tuel

Heating equipment

If diesel equipment is fre-If diesel equipment is frequently used at low air temperatures, a number of techniques can be used to prevent wax from forming. These include provision for heated fuel tanks, insulated lines, heated filters or other devices to keep fuel warm. These systems may not be cost-effective in temperate Australian climates where they may be needed

tive in temperate Australian climates where they may be needed only a few days of the year.

It is difficult to correlate Australian conditions with those of the USA because of milder conditions here. While engine block, sump and fuel heaters are available from USA sources, they are relatively available. available from USA sources, they are relatively expensive. Furthermore, they are usually designed for a 110 volt electricity supply. Historically, they have not been used in Australia except, perhaps, in the high snow country. in the high snow country.

Preparation for severely cold conditions

The most effective way to overcome fuel problems brought on by severely cold weather is to use special techniques or equipment available (from overseas sources if necessary). It includes the use of one, or a combination, of the following:

Fuel Filters. Blockage of fuel filters by wax at or below the cloud point of the fuel may be minimised by moving externally mounted fuel filters into the engine compartment or by the installation of heated fuel filters. fuel Lines, Blockage of fuel

lines may be minimised by insulating fuel lines or by the installation of fuel line heaters.

Installation of fuel line heaters. Fuel Tanks. Some truck fuel systems have their initial filtration stages which are easily blocked by wax crystals, in the fuel tank. This problem may be minimised by fuel tank insulation or the use of fuel tank hyperses.

fuel tank heaters.
Fuel Heaters, installation of a fuel heater at some point in the fuel system will rules the average temperature of the fuel at all subsequent points. Various on-board types have been developed; electrical, exhaust gas, engine-coolant and return fuel mixer systems, External fuel heaters, attached External fuel heaters, attached to the fuel system during shutdown periods, have also been used successfully where temperatures are severe. Any fuel heating device should have controls, preferably automatic, permitting it to be turned off in warm weather, and some means of thermostatic control to prevent fuel from control to prevent fuel from overheating.

Australian Institute of Petroleum Ltd

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