



The Lead Content of Petrol/Gasoline in New Zealand 1965-1975

Questions posed and answers collated by Elizabeth O'Brien, Lead Scientist, The LEAD Group Inc, Australia

The question in the heading went unanswered for months after I began investigating it, so I developed the following Q&A as steps on the way to finding the answers.

Q: is there an upper limit to the lead content of motor fuel/petrol/gasoline?

A: yes, according to *Phasing Lead out of Gasoline: An Examination of Policy Approaches in Different Countries*, by United Nations Environment Programme (UNEP) & Organisation for Economic Co-operation and Development (OECD) 1999, <https://www.un.org/esa/gite/iandm/unep-lead.pdf> :

The octane boost# due to lead does not increase linearly with lead concentration. The first 0.1 g/liter of lead additive gives the largest octane boost, with subsequent increases in lead concentration giving progressively smaller returns. ... Further, refinery modernization investments necessary to reduce the lead content of gasoline often improve productivity and refining efficiency, and can increase revenues.

Octane is a measure of the ability of a fuel to resist self detonation in the combustion chamber. In 1929, the octane scale was established in which two hydrocarbons were selected as references: one that tended to knock in an engine under almost all conditions (*n*-heptane) and the other having a much higher knock resistance than any known gasoline component at that time (*iso*-octane).

Q: how did the lead content in petrol in New Zealand compare to the lead content of gasoline in other countries and why was it so high for so long compared to other countries?

A: Chemistry in New Zealand, April 1983 Volume 47 No. 2 (pages 28-30): A Review of Lead Hazards in the Motor Service and Repair Industry, by RV Winchester, Northern Occupational Health Unit, Department of Health, Auckland, states:

...New Zealand petrol contains a relatively high level of lead alkyls compared with many other countries...

Association of Childhood Blood Lead Levels With Criminal Offending – [a publication from the Dunedin Study], by Amber L. Beckley, PhD; Avshalom Caspi, PhD; Jonathan Broadbent, PhD; Honalee Harrington, BA; Renate M. Houts, PhD; Richie Poulton, PhD; Sandhya Ramrakha, PhD; Aaron Reuben, MEM; Terrie E. Moffitt, PhD, in *JAMA Pediatr.* 2018;172(2):166-173, <http://dx.doi.org/10.1001/jamapediatrics.2017.4005> includes:



...during the Dunedin Study cohort's childhood in the 1970s and 1980s, there was evidence of the association between leaded gasoline and elevated BLLs [blood lead levels]. 34. [Ref 34. Wilson N, Horrocks J. Lessons from the removal of lead from gasoline for controlling other environmental pollutants: a case study from New Zealand. *Environ Health.* 2008;7:1.]

Lessons from the removal of lead from gasoline for controlling other environmental pollutants: A case study from New Zealand, by Nick Wilson and John Horrocks, *Environ Health.* 2008; 7: 1. Published: 7 January 2008, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2263033/> states:

The closeness of the relationship between the lead industry and New Zealand officialdom was noted by Dr Clair Patterson, from CALTECH, who was an authority on the historical exposure of humans to lead in the environment [51]. After a visit to New Zealand in 1983 (in which his views on lead in the environment were derided by the Christchurch Medical Officer of Health), Patterson subsequently wrote that there appeared to be "... an unhealthy liaison between the lead alkyl industries and public health officials in New Zealand... I was struck by the remarkable similarity of the New Zealand health official's attitude and arguments with those of officials of the Ethyl Corporation and Associated Octel" [52].

COPY

THE NEW ZEALAND REFINING COMPANY LIMITED

PETROLEUM REFINERS
MARDSDEN POINT, WHANGAREI, NEW ZEALAND

Year of: _____
Date of: CN : TS.8.0

Postal Address: P.O. Box 44, Whangarei
Telephone Address: *02342, WHANGAREI
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5 March 1979

Dr J. McKenzie-Pollock,
Medical Officer of Health,
RBFC Building,
Bunt Street,
WHANGAREI

Dear Dr McKenzie-Pollock,

In view of the considerable local interest in the subject of lead in petrol, you might like to have, for reference, the enclosed folder of papers on the subject.

The folder was prepared for a Press Conference in Australia by Associated Octel Limited, the manufacturers and suppliers of the lead alkyls used by us in the refinery. I appreciate that Associated Octel Limited have a vested interest in the supply of lead for gasoline blending, but there is no doubt in my mind that the contents of the folder clearly indicate that there are many eminent medical authorities throughout the world who disagree with the statements recently made in Auckland by Professor Bryce-Smith.

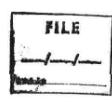
I understand that Dr M. Gilmour of 54 Basset Road, Auckland, who acts as Octel's Medical Adviser here in New Zealand, has recently discussed the lead in petrol issue with your colleagues in Wellington so perhaps you could obtain additional information from them should you so wish.

Yours sincerely,

R. J. POWELL

R. J. POWELL,
GENERAL MANAGER

Encl . . . Folder - Lead in Petrol



FOLDER CONTENTS

A. Some Environmental Health Effects of Lead

Joint comments by
Dr J.F. Cole - ILZRO
Dr P. Barry - Associated Octel Co. Ltd.

B. W.H.O. View on Relative Contributions of Lead as Relating to Adult Members of the General Population.

Excerpt from Environmental Health Criteria No. 3, Lead World Health Organisation 1977.

C. Clinical and Epidemiological Studies on the Effects of Lead ; Evaluation of Health Risk to Man from Exposure to Lead.

Excerpt from Environmental Health Criteria No. 3, Lead World Health Organisation 1977.

D. Lead Content of Petrol

Statement issued by National Health and Medical Research Council following 85th Session, June 1978.

E. Lead in the Environment and its Significance to Man.

Foreword to Report of an Inter Departmental Working Group on Heavy Metals U.K.

F. Evaluation of Long Term Effects of Elevated Blood Lead Concentrations in Asymptomatic Children.

J.L. McNeil et al, El Paso Independent School District, El Paso, Texas, USA

G. Lead Pollution in Birmingham.

Summary and conclusions to report of the Joint Working Party on Lead Pollution Around Gravely Hill ; Pollution Paper No. 14.

H. Investigation into Lead from Motor Vehicles

A.C. Chamberlain et al.
UK Atomic Energy Authority, Harwell, U.K. November 1978

I. Statement on 12.12.78 by Denis Howell, Minister of State, UK Department of the Environment.

J. Maximum Lead Content of Motor Gasoline - January 1978

Above, 19790305 NZ Refining Co supplies Associated Octel lead info to Medical Officer of Health and FOLDER CONTENTS.



19790503 Advocate newspaper article (at right) Lower lead content praised

Q: Which country had a high lead content in petrol in 1991?

A: *Lead Content of Petrol and Diesel and its Assessment in an Urban Environment*, by Pravin P. Parekh, Haider A. Khwaja, Adil R. Khan, Ronaq R. Naqvi, Abdul Malik, Khalid Khan and Ghazanfar Hussain, in *Environmental Monitoring and Assessment*, March 2002, Volume 74, Issue 3, pp 255-262, Springer Link, <https://link.springer.com/article/10.1023/A:1014296713553> states:

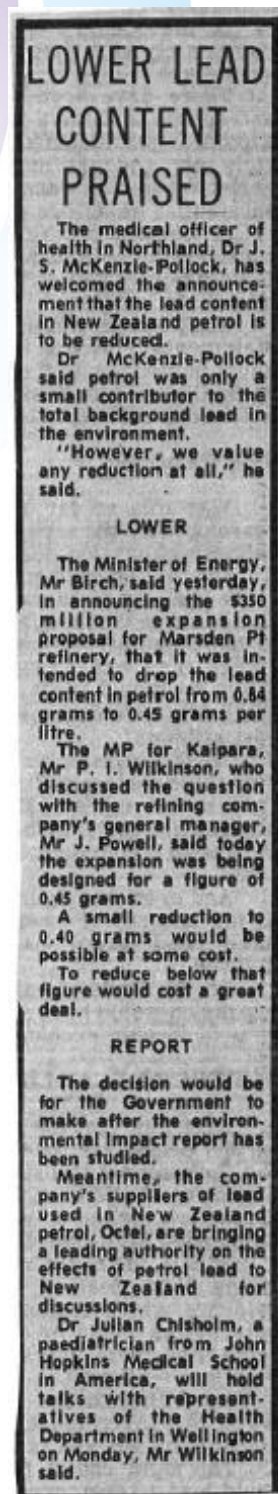
Pakistan is one of the few countries in Asia that continues to use only leaded-petrol as vehicular fuel. The concentration of Pb in its petrol reported in 1991 was the highest (1.5 – 2.0 g Pb L⁻¹) [1.5 – 2.0 g/L] of all produced by the various Asian countries and far exceeded the WHO's guideline of 0.15 g Pb L⁻¹.

... Samples of 'Regular' petrol collected in 1999 was found to contain 0.363 gPb L⁻¹ (range: 0.335 – 0.390 g Pb L⁻¹), a factor of 5 lower than that marketed prior to 1991.

Q: which country was the first to move downwards in lead content of motor gasoline?

A: *Ethyl-leaded Gasoline: How a Classic Occupational Disease Became an International Public Health Disaster*, by William Kovarik, PhD, Professor of Media Studies, Radford University, *INT J OCCUP ENVIRON HEALTH* 2005;11:384-397, <https://www.tandfonline.com/doi/abs/10.1179/oeht.2005.11.4.384> explains:

In 1973, [US] EPA announced regulations requiring a gradual reduction in the lead content of each refinery's total gasoline pool. At that time, [1973, in the United States] the average gallon of gasoline had 2.2 grams of lead [0.58 g/L]. The lead phase-down would start January 1, 1975, with a reduction to 1.7 grams [0.45 g/L] and continue to 1979 with a reduction to 0.5 grams per gallon [0.13 g/L]... Meanwhile, automakers equipped new cars with pollution-reducing catalytic converters designed to run only on unleaded fuel starting in 1975 and 1976, and new unleaded gasoline pumps began appearing at filling stations nationwide. At that time, the average blood lead level in children under age 6 was 16.5 µg/dL. By 1985, 40% of all gasoline sold was still leaded, but in July of that year, the refinery pool standard of 1.1 grams per gallon dropped to 0.5, then dropped further to 0.1 grams per gallon [0.026 g/L] on January 1, 1986. Over all, the 1986 standard represented a drop of more than 98%





in the lead content of U.S. gasoline from 1970 to 1986. With the phase-out of leaded gasoline, the average blood lead level had dropped by 1996 to 3.6 µg/dL, and it continues to decline.

Q: what was the lead content of New Zealand petrol after Associated Ocel provided an automated TEL mixing system to the New Zealand Refinery in 1977?

A: Another document (see below the two pages from 198004 NZ Refining Co Air Polluting Chemicals (Pb in petrol) in Present & Expanded Refinery) from NZ government archives refers to 0.45 g/L as being the “level specified by Ministry of Energy in 1979”, though it was clearly not a regulated limit, since the same document (apparently dating from April 1980) gives 0.84 g/L as the “current” concentration of lead in NZ petrol.

2.

Air Pollutants

There are two aspects to air pollution as a result of oil refining - emissions at the refinery itself, and emissions wherever the products are burned. This paper is primarily concerned with the former, although the latter is probably of greater public interest, particularly emissions of lead from gasoline combustion. Table 2 lists levels of contaminants in certain refinery products.

Table 3 lists five significant types of emissions from the expanded refinery and their potential sources. Only emissions of sulphur oxides and particulate matter will routinely occur in significant quantities. Hydrocarbons, other malodorous compounds, and flame emissions will only occur during short-term (emergency) situations, from minor leaks, or during infrequent catalyst regeneration at certain processing units. The general design philosophy for the expansion is to incinerate all significant quantities of hydrocarbons, hydrogen sulphide and other malodorous compounds at a flare or in a furnace before release to atmosphere.

The principal source of sulphur oxides and particulate matter from the expanded refinery will be combustion of asphaltic residue (a high sulphur and ash substance) as a refinery fuel. Although dispersion studies by New Zealand Meteorological Service predict sulphur dioxide concentrations at ground below levels of concern, this Department is conscious the discharges will be clearly visible, and the concentrations of these pollutants should therefore be reduced. Unfortunately, there is not at this time a satisfactory method for reducing emissions from combustion of asphaltic residue. However, there is a significant international effort being made into technologies for processing high sulphur crude oils (the source of the asphaltic residue) in an environmentally acceptable manner. New Zealand Refining Co Ltd are required, as a condition of their Clean Air Act licence, to keep abreast of these technologies and to report progress on the matter at regular intervals.

Table 2 : Air-polluting Contaminants in certain Refinery Products

Product	Contaminant	Specified Maximum Content	
		Present Refinery	Expanded Refinery
Gasoline	Lead	0.84 g/l	0.45 g/l*
Automotive Gas Oil (Diesel)	Sulphur	0.5%	0.3%
Light Fuel Oil	Sulphur	1.5%	1.6%
Heavy Fuel Oil	Sulphur	3.5%	3.5%
Power Station and Bunker Fuel Oil	Sulphur	4.0%	4.0%

*This is the level specified by Ministry of Energy in 1979. Public pressure and/or the impact of blending the Mobil synthetic gasoline product and/or a decision to produce an alternative octane raiser (MTBE) from Maui gas may cause a reduction in this.

Monographs on the Evaluation of Carcinogenic Risks to Humans: Volume 87 Inorganic and organic lead compounds, by International Agency for Research on Cancer (IARC), (2006) <http://publications.iarc.fr/105> includes the following data in:



Table 37

Country	Location	Year/s	Lead Concentration in Gasoline g/L
New Zealand	Christchurch	1978-81	0.84
New Zealand	Christchurch	1982-83	0.84
New Zealand	Christchurch	1984-85	0.84
New Zealand	Christchurch	1989	0.45
New Zealand	Christchurch	1994	0.2

Q: Why did the level of lead in New Zealand petrol drop from 0.84 g/L in 1984-5, down to 0.45 g/L by 1989?

A: The IARC 1978-85 level of 0.84 g/L was the lead content of petrol before the refinery upgrade/expansion. *Lessons from the removal of lead from gasoline for controlling other environmental pollutants: A case study from New Zealand*, by Nick Wilson and John Horrocks, Environ Health. 2008; 7: 1. Published: 7 January 2008, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2263033/> states:

New Zealand has only one oil refinery, operated by the New Zealand Refining Co Ltd [at Marsden Point, Whangarei]. The absence of a precautionary principle was repeatedly demonstrated in its decisions (in consultation with government), regarding the form of successive refinery expansions. The capacity to produce enough unleaded gasoline to supply the bulk of the local market was reduced by the decision to base the refinery modifications in the early 1980s around a hydrocracker, rather than a catalytic cracker [20].

NGO Power Versus Leaded Petrol in New Zealand, by John Horrocks and Nick Wilson, in *The International Journal of Environmental, Cultural, Economic & Social Sustainability*, Volume 4, Number 5, January 2008, <https://www.researchgate.net/publication/307763431> *NGO Power Versus Leaded Petrol in New Zealand* includes:

Another member of EDS [Environmental Defence Society, based in Auckland, New Zealand] was Dr David Williams, now a High Court Judge#. In 1974 he was a member of a special committee of the Clean Air Council set up to report on vehicle emissions. In a dissenting statement, he suggested that the committee's recommended schedule for a lead phasedown to 0.45 g/l by 1 January 1981, or by the completion date of extensions to New Zealand's refinery, needed to be more far-reaching and the aim should be a reduction to 0.15 g/l by 1980 (Clean Air Council, 1974).

according to *Once were judges: Life in the law after 'the Bench'* by Nick Butcher in *New Zealand Law Society Lawtalk* 922, 09 October 2018,



<https://www.lawsociety.org.nz/practice-resources/practice-areas/courts/once-were-judges-life-in-the-law-after-the-bench> :

...former Justice David Williams, better known now as Sir David Williams QC...was appointed in 1992 to the High Court but resigned in 1994...[and is] One of the best arbitrators in the world...is a barrister and arbitrator at Bankside Chambers... on Shortland Street. *Chambers Global 2014* listed Sir David as among the top 40 most in-demand arbitrators worldwide for public international law, and he is frequently appointed to arbitrations involving Treaty-based disputes.

Waste Management Guide: 03. Treatment and disposal of leaded petrol sludges, by Health Protection Programme, Department of Health, Wellington, New Zealand, (September 1988)

[http://www.moh.govt.nz/notebook/nbbooks.nsf/o/4F9340FoFA162AC54C2565D7000E18F7/\\$file/treatment-disposal-leaded-petrol-sludges.pdf](http://www.moh.govt.nz/notebook/nbbooks.nsf/o/4F9340FoFA162AC54C2565D7000E18F7/$file/treatment-disposal-leaded-petrol-sludges.pdf) finally answers the question:

In July 1986, with the completion of the expansion of the Marsden Point refinery the lead content of 96-octane petrol was reduced from 0.84 g/l to 0.45 g/l.

Q: surely a New Zealand government agency would hold documents with the answer to the question: What was the lead content of petrol in New Zealand from 1965-1975?

A: I sent emails asking this question to the following New Zealand government agencies:

New Zealand Ministry for Energy (MfE)
New Zealand Ministry of Transport
New Zealand Ministry of Business, Innovation & Employment (MBIE)
Statistics New Zealand
New Zealand Transport Agency
New Zealand Ministry of Health
New Zealand Parliamentary Information Service

All replied to my emails and although no agency had any information to answer the question, the most useful reply, from the New Zealand Parliamentary Information Service, pointed out that **the first time** the lead content of petrol was regulated in New Zealand was in 1988 (after it had already been reduced to 0.45 g/l in July 1986) when it was limited to 0.45 grams per litre. See the First Schedule Requirements for Leaded Petrol, in *Ministry Of Energy (Petroleum Products Specifications) Regulations 1988*

http://www.nzlii.org/nz/legis/num_reg/moepsr1988694/ - this regulation also set a 5% benzene volume mass limit.

The final time that the lead content of New Zealand petrol was limited was in 1995. The 1995 regulations came into force on 1st January 1996, in readiness for the final phaseout of leaded petrol. See *Ministry of Commerce (Petroleum Products Specifications) Regulations 1995*, http://www.nzlii.org/nz/legis/num_reg/ppsr1995488/ which in both the First Schedule – Requirements for Regular Grade Petrol (minimum 91 octane), and the Second Schedule – Requirements for Premium Grade Petrol (minimum 95 octane) set the limit for lead to 0.013 grams per litre – which indicates no lead was permitted to be added, as 0.013



g/L is the usual maximum natural contaminant lead content of crude oil and therefore all unleaded refinery products. This 1995 regulation also kept the 5% benzene volume mass limit for both grades of petrol, introduced in the 1988 regulation (above).

In terms of what might have been the lead content of petrol, the NZ Parliamentary Information Service also advised:

Although in the NZ Gazette of 1969 (p. 794) http://www.nzlii.org/nz/other/nz_gazette/1969/24.pdf ... there was a British Standard on petrol being considered for adoption.

The British Standard listed on page 794 as under consideration (pending comments from interested parties) was:

4040: Petrol for motor vehicles-4040: Part 1: 1967 Specification and nomenclature for grades of petrol. Amendment No. 1 90.

I was able to find the following fuller description of the Standard online, but not the actual standard. Can anyone tell me what the lead content of petrol was limited to in this standard? That is: **Standard Number: BS 4040-1-1967. Title: Petrol for motor vehicles. Specification and nomenclature for grades of petrol. Publication Date:** 1967/3/9. **International Classification for Standards (ICS) :** [PETROLEUM AND RELATED TECHNOLOGIES](#)>>[Fuels](#)>>[Liquid fuels](#). **Publisher:** British Standards. **Number of Pages:** 16.

According to *History of the European Oil and Gas Industry*, Edited by J. Craig, F. Gerali, F. MacAulauy and R. Sorkhabi, in Geological Society Special Publication 465, 2018, <https://books.google.com.au/books?id=szdpDwAAQBAJ&pg=PA37&lpq=PA37&dq=BS+4040:1967?&source=bl&ots=KS3Rprf2Mr&sig=ACfU3UohZ91hWmVWqyjdkg9NvzXOQa5m6g&hl=en&sa=X&ved=2ahUKEwjHqJzi4ePkAhUHU3oKHRSKBE4Q6AEwAXoECAgQAQ#v=onepage&q&f=false> :

[BS 4040-1 : 1967] became mandatory in **1976** when the [British] government introduced a statutory instrument (**1976 SI number 1866**).

When I later discovered that UK lead (Pb) content of petrol in 1968 ranged from

0.82 g Pb/USG (0.217 g Pb/L) to 3.15 g/USG (0.832 g/L), and made the assumption that the actual UK petrol lead limits possibly voluntarily matched those in **BS 4040-1-1967**, I realized that if the British standard had been adopted in New Zealand in 1969 (it wasn't) then the NZ Premium grade lead content of 0.84 g/L would have been reduced slightly – if it was matching the UK 5 star grade upper limit, or significantly – if it was matching the UK 4 star grade upper limit of 2.69 g/USG (0.711 g/L). I'm guessing it was the NZ Refinery that put the kybosh on the British Standard being adopted in New Zealand...



ORAL QUESTIONS TRANSFERRED FOR WRITTEN ANSWER

Geothermal Field, Kawerau

17. Mr McLEAN (Tarawera) to the Minister of Energy: In view of the 2-year delay in the large-scale development of the Kawerau geothermal field, because of fear of subsidence of land at the north of the town, is he considering the reinjection of geothermal fluids to minimise subsidence and pollution?

Hon. W. F. BIRCH (Minister of Energy) replied: Yes, reinjection of geothermal fluids at Kawerau is being considered to minimise any subsidence. The Ministry of Works and Development is monitoring the field for subsidence.

Lead-free Petrol

18. Mr CAYGILL (St. Albans) to the Minister of Energy: Is he aware of the recent decision of the Labour Government in New South Wales to introduce lead-free petrol in that State from 1 July 1984, and what steps is he taking to ensure its similar availability in this country?

Hon. W. F. BIRCH (Minister of Energy) replied: It is not the Government's intention to introduce lead-free gasoline in New Zealand. The present lead level of 0.84 g per litre of gasoline will be reduced to 0.45 g per litre as soon as the refinery expansion comes on stream, and this is at present scheduled for early 1984. This level of 0.45 g per litre is recognised by most EEC and OECD countries as being a reasonable compromise between the energy conservation provided by high lead levels and the desire to reduce those levels for environmental reasons. Work is now being carried out by my ministry pursuant to the recommendation about lead in the environmental impact audit for the refinery expansion, looking at alternative ways of providing octane numbers in petrol, and their economic and

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Oral Questions Transferred for Written Answer

22 August

environmental effects.

The NZ Parliamentary Information Service also directed me to this New Zealand Parliament Question and Answer (above) *Oral Question from Mr Caygill (St Albans): NSW will introduce Lead-free Petrol on 1 July 1984? What about NZ? Written Answer by Mr Birch (Minister of Energy [New Zealand]) given on 22 August 1981*, from Parliamentary Debates: Volume 432 New Zealand Parliament. House of Representatives, January 1, 1981. Published on Dec 31, 1981. Pp 2901-2902. <https://play.google.com/store/books/details?id=9nUrAQAAIAAJ&rdid=book-9nUrAQAAIAAJ&rdot=1> indicates no intention on the part of the Minister to reduce the NZ petrol lead level prior to the refinery expansion, due to the cost: "The present lead level of 0.84g/L [provides] energy conservation."



Q: is there any other evidence that petrol lead levels were higher in New Zealand from 1965-1975 when Brian Arndt worked at the refinery?

A: Brian Arndt: The environmental issue was studied by Aaron Reuben from Duke University and others, where they tested a Dunedin cohort of kids born in 1972 to 1973 for their blood lead level at age 11 years, and re-examined them including in 2012 when they were 38 years old but all of them are in lower socio-economic jobs, quite a lot of them have a history of domestic violence and all of them have early signs of Alzheimers.

The following quotes from *Association of Childhood Blood Lead Levels With Cognitive Function and Socioeconomic Status at Age 38 Years and With IQ Change and Socioeconomic Mobility Between Childhood and Adulthood [Dunedin cohort]*, by Aaron Reuben, MEM; Avshalom Caspi, PhD; Daniel W. Belsky, PhD; Jonathan Broadbent, PhD; Honalee Harrington, BA; Karen Sugden, PhD; Renate M. Houts, PhD; Sandhya Ramrakha, PhD; Richie Poulton, PhD; Terrie E. Moffitt, PhD, in JAMA March 28, 2017 Vol 317, Number 12,

https://jamanetwork.com/journals/jama/fullarticle/2613157?utm_campaign=articlePDF&utm_medium=articlePDFlink&utm_source=articlePDF&utm_content=jama.2017.1560 support Brian Arndt's contention that petrol lead content in New Zealand was higher than in many other countries when he worked in the New Zealand refinery from 1965-1975, and goes on to support Brian's summary of the conclusions drawn (published in 2017) from the 2012 38 year old follow-up assessment:

The Dunedin Multidisciplinary Health and Development Study observed a population-representative cohort of children born in New Zealand in 1972-1973. The most recent assessment included cognitive and socioeconomic evaluations and was completed when participants were 38 years old. In the 1970s and 1980s, lead exposures in New Zealand cities were consistently higher than international standards, largely due to poor air quality related to motor vehicle emissions.¹⁰ Consequently, childhood blood lead levels in the Dunedin cohort were similar to those of other cohorts tested in the early 1980s from larger developed cities.^{11,12} However, unlike with other cohorts,^{13,14} a social gradient in lead exposure was not observed. This provided an opportunity to test the hypothesis that childhood lead exposure is associated with cognitive impairment and downward socioeconomic mobility by midlife without having to disentangle such exposure from correlated socioeconomic disadvantages.

Analyses also tested whether the association between blood lead levels and downward social mobility was mediated by cognitive decline....

Conclusions...:

In this cohort born in New Zealand in 1972-1973, childhood lead exposure was associated with lower cognitive function and socioeconomic status at age 38 years and with declines in IQ and with downward social mobility....



The following extracts support Brian Arndt's summary of the findings of the 38 year follow-up of the Dunedin cohort.

Association of Childhood Lead Exposure with Adult Personality Traits and Lifelong Mental Health, by Reuben, Aaron; Schaefer, Jonathan; Moffitt, Terrie; Broadbent, Jonathan; Harrington, Honalee; Houts, Renate; Ramrakha, Sandhya; Poulton, Richie; Caspi, Avshalom, *JAMA Psychiatry*. Published online January 23, 2019;76(4):418-425. <https://jamanetwork.com/journals/jamapsychiatry/fullarticle/2720691> concludes:

In this multidecade, longitudinal study of lead-exposed children, higher childhood blood lead level was associated with greater psychopathology across the life course and difficult adult personality traits.

Association of Childhood Blood Lead Levels With Criminal Offending, by Amber L. Beckley, PhD; Avshalom Caspi, PhD; Jonathan Broadbent, PhD; Honalee Harrington, BA; Renate M. Houts, PhD; Richie Poulton, PhD; Sandhya Ramrakha, PhD; Aaron Reuben, MEM; Terrie E. Moffitt, PhD, *JAMA Pediatr*. 2018;172(2):166-173, <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2666777> says:

Findings In this cohort study of 553 New Zealanders observed for 38 years, lead exposure in childhood was weakly associated with official criminal conviction and self-reported offending from ages 15 to 38 years....

A total of 154 participants (27.8%) had a criminal conviction, 68 (12.3%) were one-time offenders, 86 (15.6%) had recidivated, 101 (18.3%) were nonviolent offenders, and 53 (9.6%) were violent offenders. Criminal conviction was more prevalent and more frequent at higher BLLs: 8 of 33 participants (24.2%) with a BLL of 5 µg/dL or less had a criminal conviction compared with 24 of 82 participants (29.3%) with a BLL above 15 µg/dL.

Childhood Lead Exposure and Adult Neurodegenerative Disease, by Aaron Reuben, Department of Psychology and Neuroscience, Duke University, Durham, NC, USA, in *Journal of Alzheimer's Disease* 64 (2018) 17-42, <https://content.iospress.com/articles/journal-of-alzheimers-disease/jad180267> refers to the above Reuben et al 2017 article as Reference [84] and concludes:

This year [2017] the oldest age follow-up in lead exposed children, in a population-representative cohort of New Zealanders born in 1972–1973, reported evidence of cognitive deficits in middle-aged adults exposed to lead as children and, further, of cognitive decline across the 30 years preceding follow-up [84]. As noted earlier in this review, cognitive deficits relative to peers and cognitive decline measured across many years represent risk factors for AD [Alzheimer's Disease], although these are generally used as risk predictors in older populations (e.g., those >65 years old).



Q: How did New Zealand’s lead content in petrol compare to Australian states and territories?

A: Quantification of atmospheric lead emissions from 70 years of leaded petrol consumption in Australia, by Louise Jane Kristensen, in Atmospheric Environment 111 (2015) 195-201,

<https://www.sciencedirect.com/science/article/pii/S1352231015300157?via%3Dihub>

gives the following graph showing all states and territories at the start of the graphed period, in 1973, had the same lead content in petrol – 0.84 g/L – as New Zealand had from at least 1978 to July 1986, but only the Northern Territory (NT), Queensland (QLD) and rural New South Wales (NSW 2) maintained that level beyond 1976 (until the early 1990s):

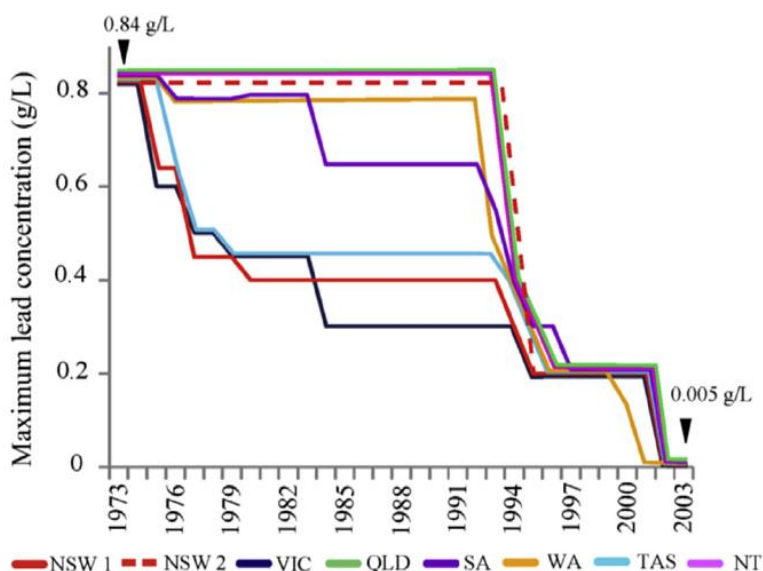
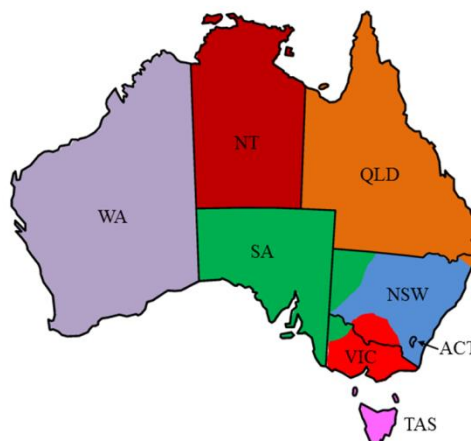


Fig. 1. The reduction of maximum lead in petrol concentrations for state and territories of Australia. (ACT) is included in the NSW state marketing area.

Supplementary Figure S1 [MAP]: State marketing areas for leaded petrol sales (adapted from Australian Institute of Petroleum¹). The state marketing areas used for the sales of leaded petrol follow the state borders with the following exceptions: the Murwillumbah district in New South Wales (NSW) is included in the Queensland (QLD) state marketing area, the Broken Hill-Wilcannia district of NSW and the Murrayville district of Victoria (VIC) are included in the South Australia (SA) state marketing area, the Riverina district of NSW is included in the VIC state marketing area and the Australian Capital Territory



Louise Kristensen’s **Supplementary Table S2:** Concentration of lead in petrol in Australia...from 1964... gives the following lead in petrol ranges for the period from 1964 to 1969:

1964	0.25-0.84 g/L ♦ 0.17-0.72 g/L * ³⁴
1967	0.84 g/L * ³⁵
1968	0.17-0.84 g/L ♦ 0.00-0.75 g/L * ³⁶
1969	0.17-0.84 g/L ♦ 0.00-0.75 g/L * ³⁷

KEY: * Petrol regulation; # Actual lead concentration averages; ♦ Premium grade petrol; * Regular grade petrol



The excerpt (above) from **Supplementary Table S2** implies that 1967 was the first year in Australia when the maximum lead content of petrol was limited by regulation. That's 21 years earlier than when the lead content of petrol in New Zealand was limited by regulation (1988), as stated above.

But most importantly, the references for the information in the graph (Fig. 1 above) and in the Supplementary data for the Kristensen 2015 paper, for the relevant period in New Zealand (1965-1975) were listed as:

1. Associated Octel, 1964. World-wide Survey of Motor Gasoline Quality - May 1964. The Associated Octel Company Limited, London.
2. Associated Octel, 1968. World-wide Survey of Motor Gasoline Quality - May 1968. The Associated Octel Company Limited, London.
3. Associated Octel, 1969. World-wide Survey of Motor Gasoline Quality - May 1969. The Associated Octel Company Limited, London.
4. Associated Octel, 1975. World-wide Survey of Motor Gasoline Quality - May 1975. The Associated Octel Company Limited, London.

And when I searched World Catalogue for these Octel issues, all four were listed as being at the New Zealand Ministry of Business, Innovation & Employment (MBIE). When I asked MBIE again for the information, they said they couldn't find the Octel documents but if I came into the Wellington office of New Zealand Archives (from Sydney, Australia), I could read issues dating from 1970 onwards, of *Oil industry - Motor Vehicle Emissions - Lead Content of Petrol - Technical Studies*. Thankfully my New Zealand colleague John Horrocks agreed to check out the documents for me and on 25th September 2019, John reported (personal communication by email):

Re: *Oil industry - Motor Vehicle Emissions - Lead Content of Petrol - Technical Studies* (R17158262) 1970-1979. Unfortunately this was only a collection of papers about technical features of lead in petrol, with no reference to New Zealand or mention of health issues... focus was on vehicle performance, measures of RON, MON, lead traps etc. (Authors: Texaco, Ethyl Corp., Esso, Du Pont, National Petroleum Refiners Assn.)

In his searching though, John Horrocks did find the following proposed phase-down of the lead content of petrol, from the *Report of the Motor Vehicle Committee on Proposed Motor Vehicle Emission Standards*, 1974, published by Department of Health, Wellington, New Zealand. Note that the proposed first reduction in lead content down to 0.82 g/L in 1974 implies that at the time of writing (possibly late 1973 or early 1974), the lead content of New Zealand petrol was higher than 0.82 g/L:

SUMMARY OF RECOMMENDATIONS

...

4. That until the oil refinery expansion takes place the maximum lead content of gasoline should be progressively reduced at least in accordance with the following programme:



Year	Premium gasoline lead level
	g/L
1974	0.82
1976	0.78
1978	0.71
1980	0.68

John Horrocks goes on to point out (in his 25th Sept 2019 email):

The personnel on the committee were all engineers, with the exception of D.A.R. Williams, a highly-qualified Auckland lawyer [see above note about David Williams now being a barrister and arbitrator] who was also a member of the Environmental Defence Society. His 8 page long dissenting opinion called for a much more rapid move to reduce lead content, and was notable for the references he made to rulings by the US EPA and early research on the health effects of lead on children. It is a far-sighted and implicit rebuke to the other members of the committee, who were too reliant on data provided by the oil industry. There was, however, no mention of the danger of the lead additives themselves, except for their role in vehicle emissions, and an alarming lack of any sense that the committee (with the exception of Williams) had drawn on advice from health experts. The thrust was very much about how much it might cost to reduce lead in petrol. The aim [of the New Zealand oil industry proposal ie the phasedown steps listed above] was to ensure that the amount of lead emitted did not increase as the vehicle fleet grew!!! "The aim would be to prevent increase in the overall amount of lead emitted..."

And of course, in the end, nothing was legislated until 1988 (when New Zealand lead content of petrol was limited for the first time, to 0.45 g/L) and the oil refinery expansion completed in July 1986 had already ensured that the lead content was reduced from 0.84 g/L – ie, no steps were taken to phase out the lead from New Zealand petrol.

Also on 25th September 2019, the National Library of Australia finally found and made available to me by Inter-Library Loan, their only issue of *World-wide Survey of Motor Gasoline Quality* - May 1968, by The Associated Ocel Company Limited, London. And if the company that makes the TEL/TML additives for petrol are to be believed, then this was the first written evidence of the lead content in New Zealand petrol in the period 1965-1975. *World-wide Survey of Motor Gasoline Quality* - May 1968 gives the following information:

The Summary on page 4 says New Zealand increased by one RON in both Premium and Regular grades; the Preface on page 5 says info for this May 1968 survey was gathered in the first two months of 1968, implying that Associated Ocel published a *World-wide Survey of Motor Gasoline Quality* annually, rather than as irregularly as indicated by the references quoted by Kristensen (2015) above. Page 58 shows New Zealand with up to 3.17 g Pb per US Gallon which converts to 0.8374 or 0.84 g Pb per Litre and the same figure is given as the highest in the range for several other countries/grades on page 58 ie: Australia, Guam, Hawaii, Marshall Islands also with 3.17 g Pb per US Gallon - 0.84 g Pb per Litre.



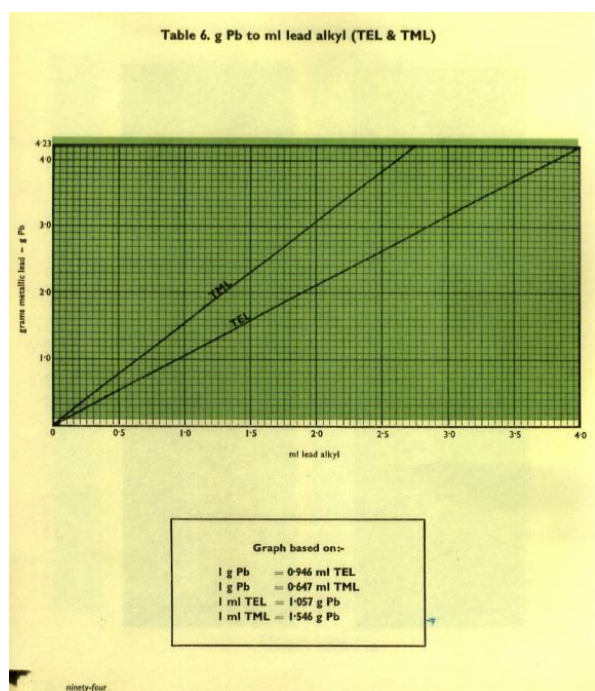
I find it fascinating and mysterious how Pakistani petrol was found to contain 1.5-2.0 g Pb per Litre in 1991...when Pakistan (East & West) is given as having one grade in January-February 1968 with a lead content range from 0.84-2.11 Pb per US Gallon – 0.222-0.557 g Pb per Litre... perhaps the 0.84-2.11 was already in g Pb per Litre??? Page 92 would seem to imply that 1.12 g Pb per Litre is the highest lead content possible, so again, what about Pakistan in 1991 – did the researchers (Parekh et al, mentioned above) just get it wrong?

So, if Associated Octel is to be believed, the lead content of New Zealand petrol (see excerpts below from the World-wide Survey) was 0.84 g/L in January and February of 1968 and that may be the oldest written record to be found in Australia and New Zealand.

Grade	Range of Octane Number		Range of Lead Content per USG		
	Research method	Motor method	ml TEL	g Pb	
New Zealand Premium	↑	97	93	3.0	3.17
	↓	96	89	2.3	2.43
Regular	↑	84	83	2.6	2.74
	↓	83	81	0.4	0.42

Lead Content of New Zealand Petrol in January-February 1968

Grade	Range of RON	Range of Lead Content Per US Gallon		Range of Lead Content Per Litre	
		ml TEL	g Pb	ml TEL	g Pb
Premium	97-96	3.0-2.3	3.17-2.43	0.79-0.61	0.84-0.64
Regular	84-83	2.6-0.4	2.74-0.42	0.69-0.11	0.72-0.11



Graph [at left] based on:

- 1 g Pb = 0.946 ml TEL
- 1 g Pb = 0.647 ml TML
- 1 ml TEL = 1.057 g Pb
- 1 ml TML = 1.546 g Pb