Relationships Between Cutter Oil Properties and Sprayed Seal Performance

11 July 2019

Austroads

Today’s moderator

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Austroads acknowledges the Australian Aboriginal and Torres Strait Islander peoples as the first inhabitants of the nation and the traditional custodians of the lands where we live, learn and work. We pay our respects to Elders past, present and emerging for they hold the memories, traditions, culture and hopes of Aboriginal and Torres Strait Islander peoples of Australia.

Austroads acknowledges and respects the Treaty of Waitangi and Maori as the original people of New Zealand.

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The peak organisation of Australasian road transport and traffic agencies

- Transport for NSW
- Roads Corporation Victoria
- Department of Transport and Main Roads Queensland
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Regional Development and Cities
- Australian Local Government Association
- New Zealand Transport Agency

Our structure

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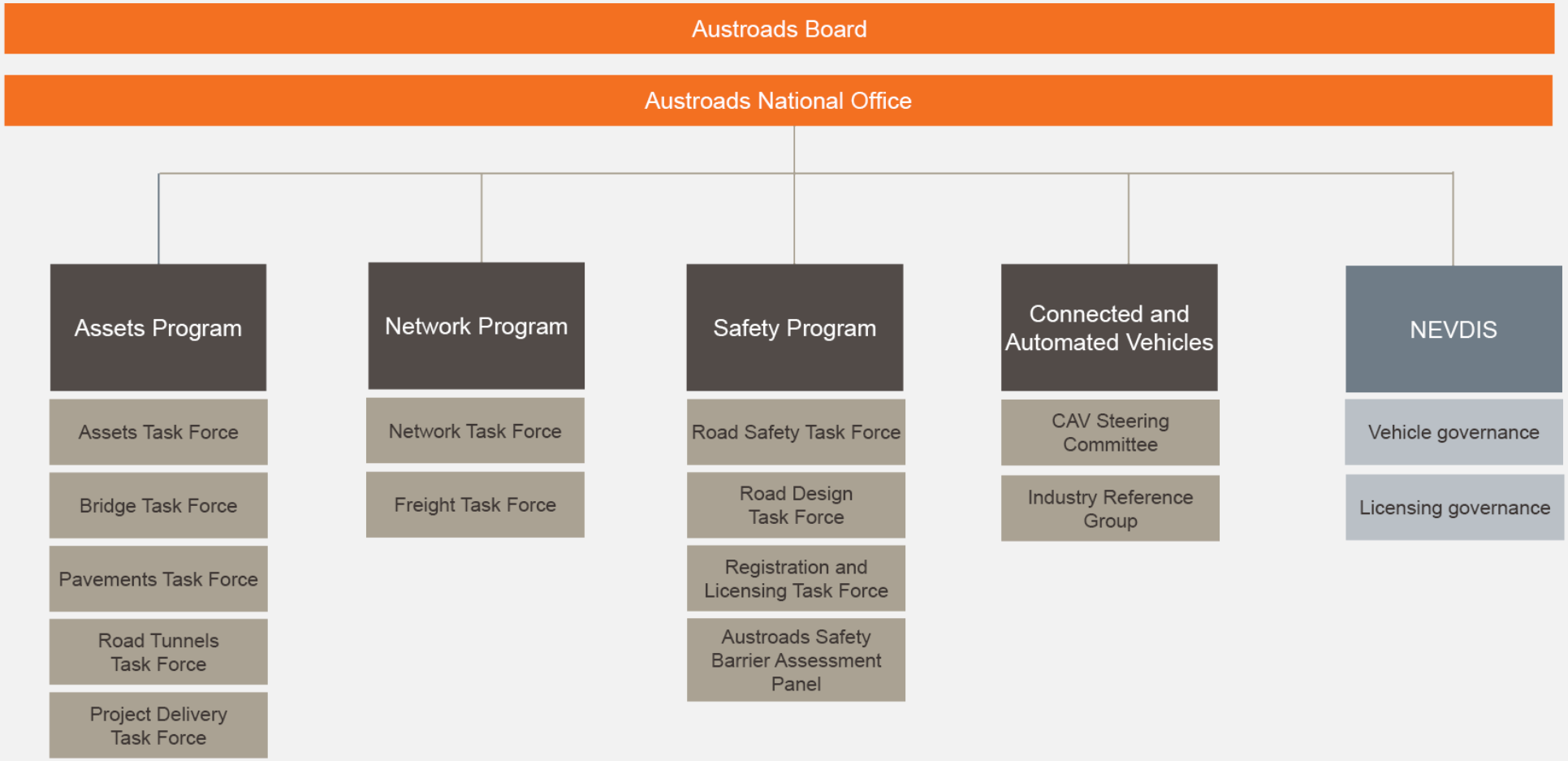

Housekeeping

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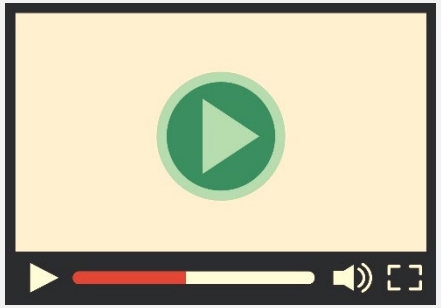
Presentation = 40 mins

Question time = 15 mins



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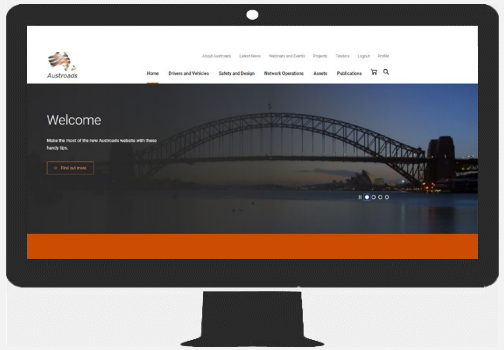

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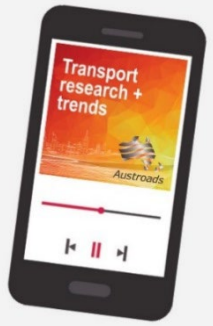

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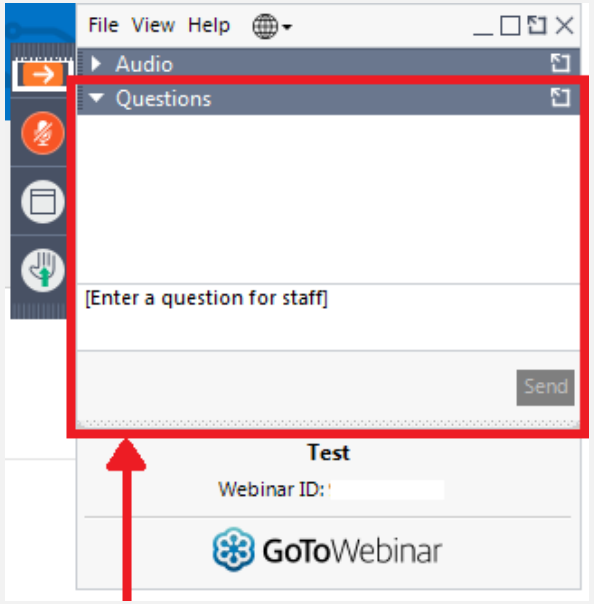

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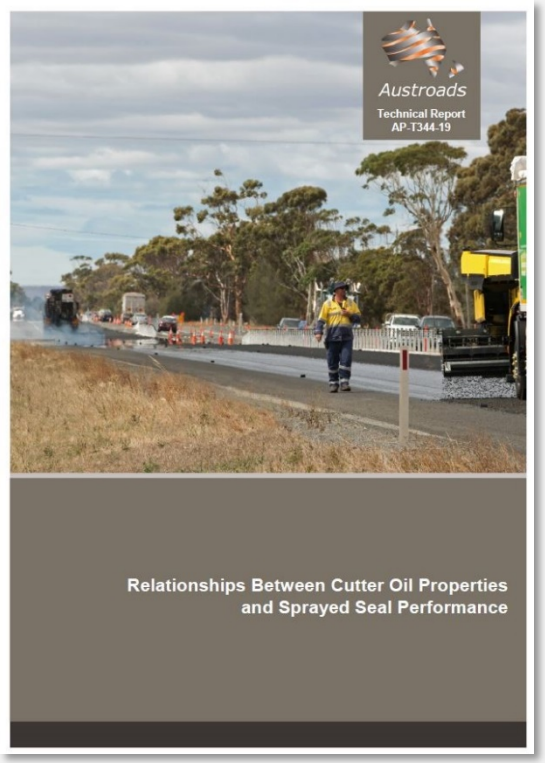

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Today’s presenter

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Agenda

Topic	Presenter
Project Background and Introduction	Robert Urquhart
Cutter Oils Studied	
Summary of Performance Test Results	
Proposed Revisions to AS 3568	
Summary and AS 3568 Revision Status	
Q&A	

Project Background and Introduction

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Introduction to team

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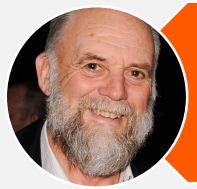
Project Team



Project Manager, VicRoads
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Project Leader, ARRB
Robert Urquhart

Team Member, Monash University
Afifa Tamanna

Team Member, ARRB
Steve Patrick

Review Team

Austroads Bituminous Surfacings Working Group (BSWG)

Stakeholders- Road Agencies and Industry

Austroads Pavements Task Force (PTF)

The Project Team

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Austroads Bituminous Surfacings Working Group (BSWG)

The Project Team

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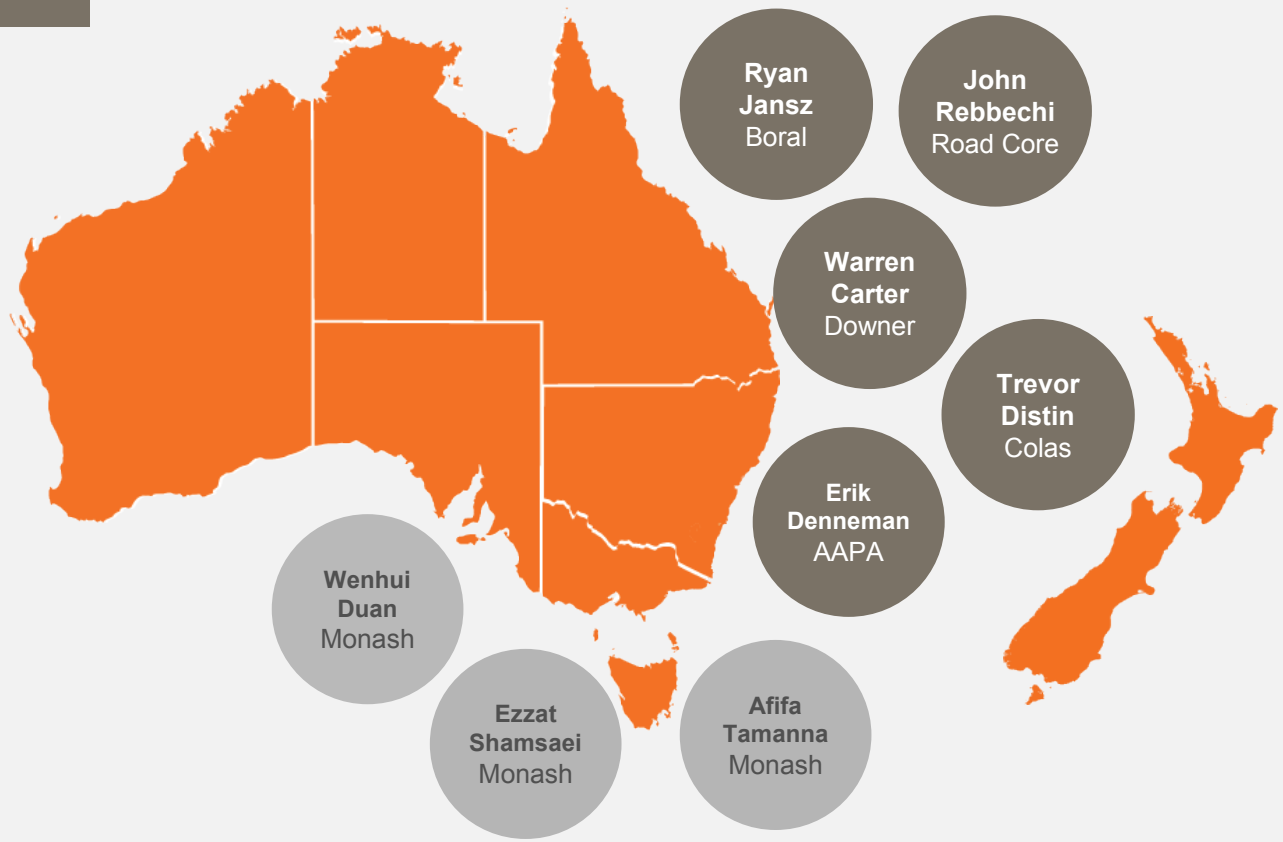
Stakeholders – Industry

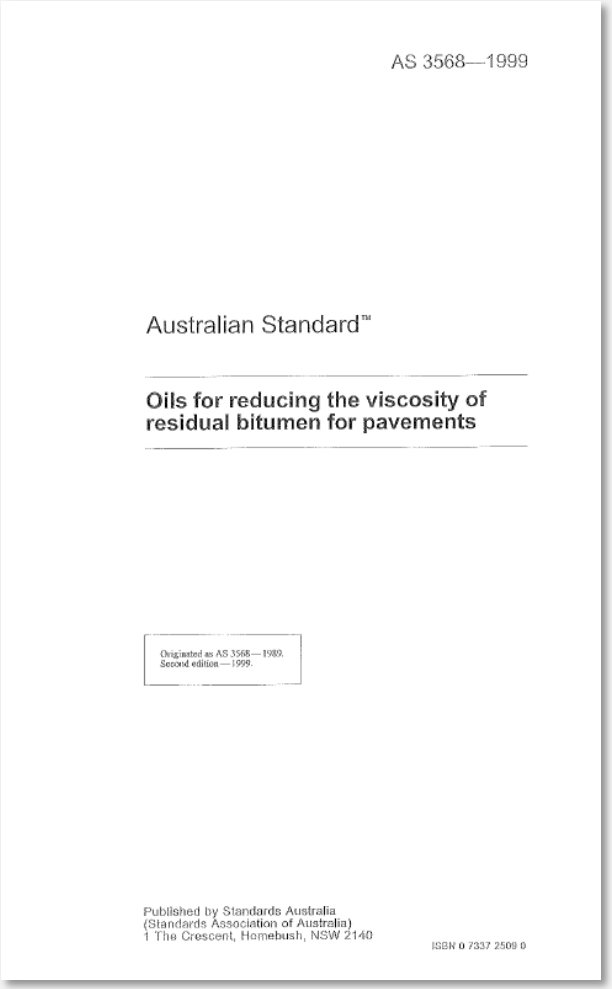


Project Background

- Cutter oils (cutters) are added to hot binders during sprayed seal construction to enhance binder-aggregate adhesion at low pavement temperatures (20–45 °C)
- Australian Standard AS 3568 is used to specify the properties of:
  - cutter oil, high flash point cutter, flux oil and heavy flux oil.

Project Background

- AS 3568 was last updated in 1999 and specifies some materials that are no longer commercially available
- Some materials that fail AS 3568 requirements appear to perform satisfactorily during sprayed seal construction.



AS 3568—1999

Australian Standard™

Oils for reducing the viscosity of residual bitumen for pavements

Originated as AS 3568—1989.
Second edition—1999.

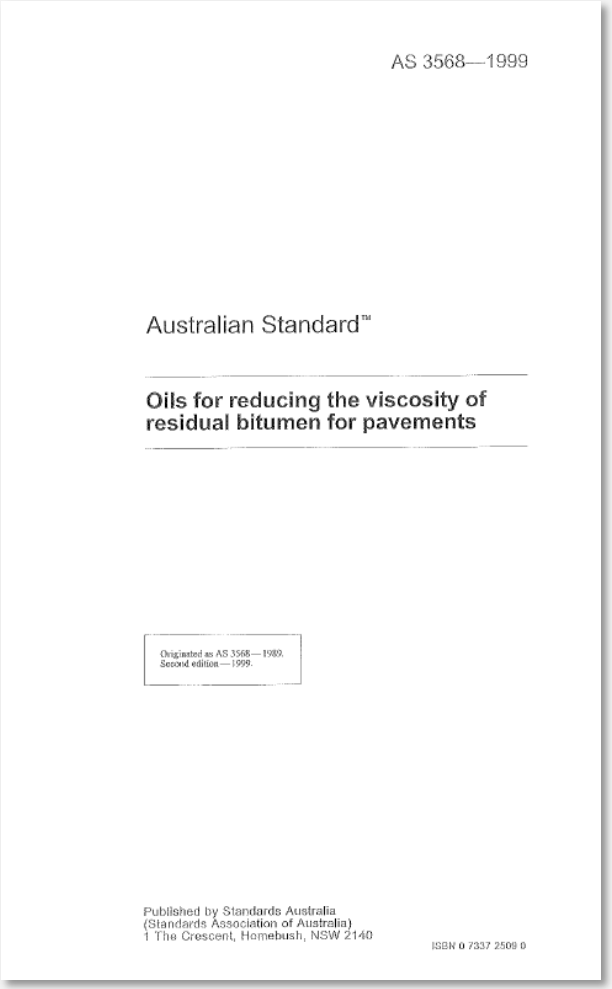
Published by Standards Australia
(Standards Association of Australia)
1 The Crescent, Homebush, NSW 2140

ISBN 0 7337 2509 0

Project Aim

To identify the key properties of cutters which affect sprayed seal performance so that AS 3568 can be updated so that it is:

- more performance-based
- allows the use of currently available commercial oils.



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Current AS 3568 tests

‘Performance’-related properties	Handling properties
Aniline point or aromatic content (chemical properties)	Flash point (flammability)
Distillation properties (e.g. IBP or FBP)	Water content (restricts foaming)
Viscosity at 40 °C	Fluidity (liquid and free of particulate matter)
Miscibility with bitumen	Density at 15 °C (converts L to kg)

Project Overview

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- During the study 7 different commercially available oils were initially subjected to a range of AS 3568-specified tests
- These test results were then compared to those obtained in 4 laboratory sprayed seal performance tests which were performed after the oils were blended with C170 bitumen.

Project Overview – Performance Tests

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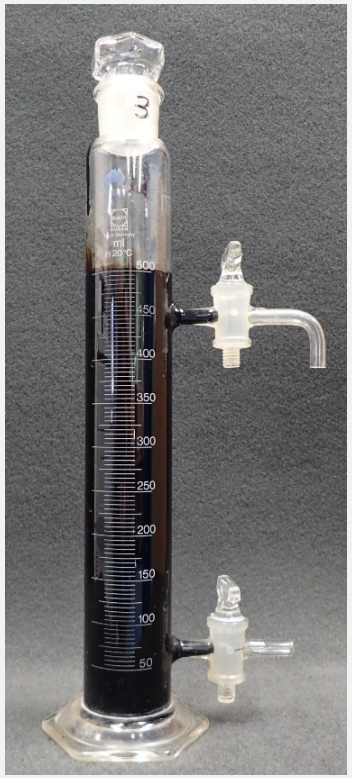
Oil miscibility



Aggregate wetting

Rate of oil loss

C170 viscosity reduction and effects on AP-T39/05 recommended cutter levels

Cutter Oils Studied

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Oils studied

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- Jet A1 (conventional cutter)
- Viva Energy High Flash Cutter (conventional high flash point (HFPC) cutter)
- Diesel (conventional flux oil)
- Mineral turpentine (solvent)
- Enersol kerosene (solvent with a similar boiling point range to Jet A1)
- Enersol K (solvent)
- Enersol HFK (HFPC)

AS 3568 test results – conventional oils

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Test	Jet A1 (cutter oil)	HFPC (HFPC)	Diesel (flux oil)
Aniline point (°C)	59	63	71
Aromatic content (% v/v)	15	17	24
Density at 15 °C (kg/m^3)	795	814	847
Viscosity at 40 °C (mPa s)	0.90	1.26	2.82
Initial boiling point (IBP) (°C)	162	202	193
% vol. recovered at 150 °C (%)	0	0	0
% vol. recovered at 200 °C (%)	66	0	1
% vol. recovered at 250 °C (%)	100	100	15
% vol. recovered at 300 °C (%)	100	100	68
% vol. recovered at 350 °C (%)	100	100	96
Final boiling point (FBP) (°C)	232	236	358

AS 3568 test results – other oils

Austroads

Test	Mineral Turpentine (cutter oil)	Enersol kerosene (cutter oil)	Enersol K (HFPC)	Enersol HFK (HFPC)
Aniline point (°C)	23	74	81	83
Aromatic content (% v/v)	45	3	7	7
Density at 15 °C (kg/m^3)	813	761	794	797
Viscosity at 40 °C (mPa s)	0.66	0.83	1.66	1.85
Initial boiling point (IBP) (°C)	149	148	194	184
% vol. recovered at 150 °C (%)	0	0	0	0
% vol. recovered at 200 °C (%)	100	78	0	2
% vol. recovered at 250 °C (%)	100	100	54	46
% vol. recovered at 300 °C (%)	100	100	100	83
% vol. recovered at 350 °C (%)	100	100	100	100
Final boiling point (FBP) (°C)	184	234	286	336

Summary of Performance Test Results

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1) Bitumen-oil miscibility

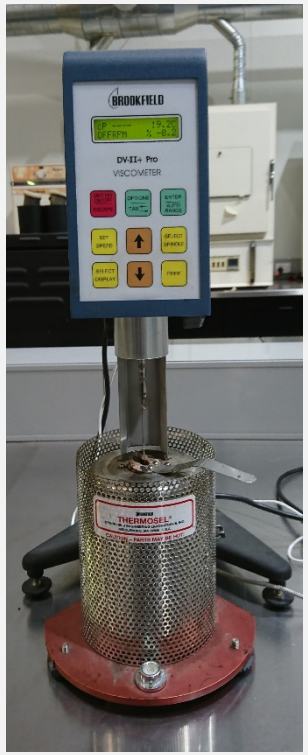
60% w/w C170 bitumen / 40% w/w oil

3 days storage, room temperature

(AS/NZS 2341.27)

Top 50 ml

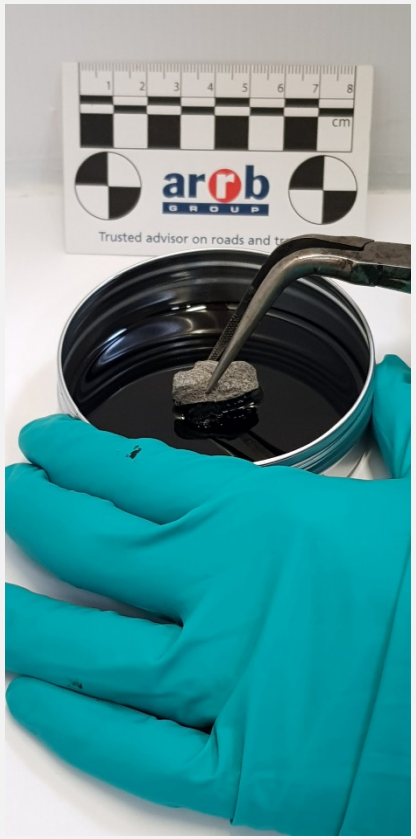
Bottom 50 ml



Viscosity at 60 °C (AS/NZS 2341.4)

None of the bitumen/oil blends separated during storage

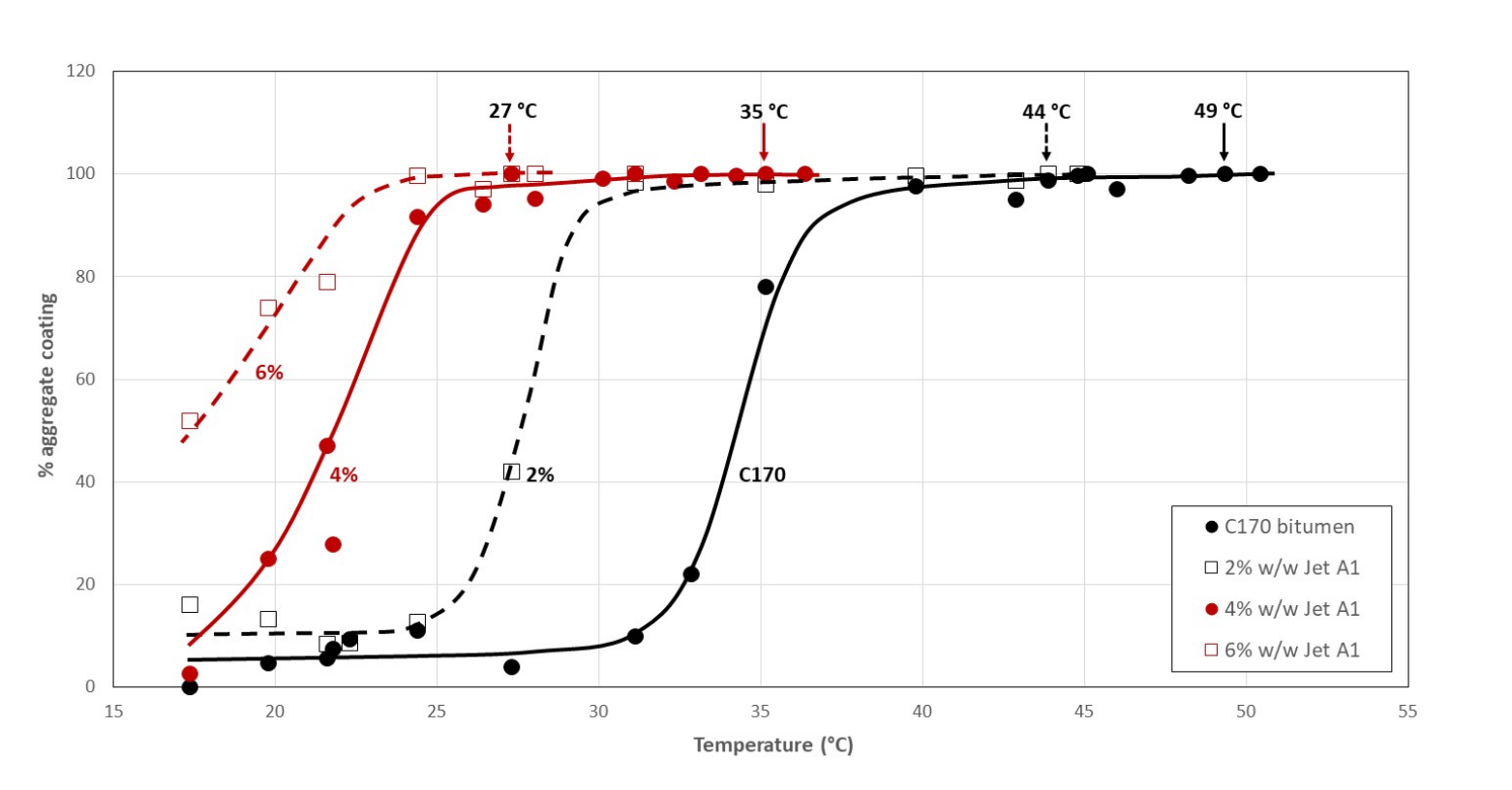
2) Aggregate wetting performance



2 mm films: 0%, 2%, 4% 6% w/w of each oil

Temperature: 17 – 50 °C

Aggregate wetting performance (Jet A1 blends)



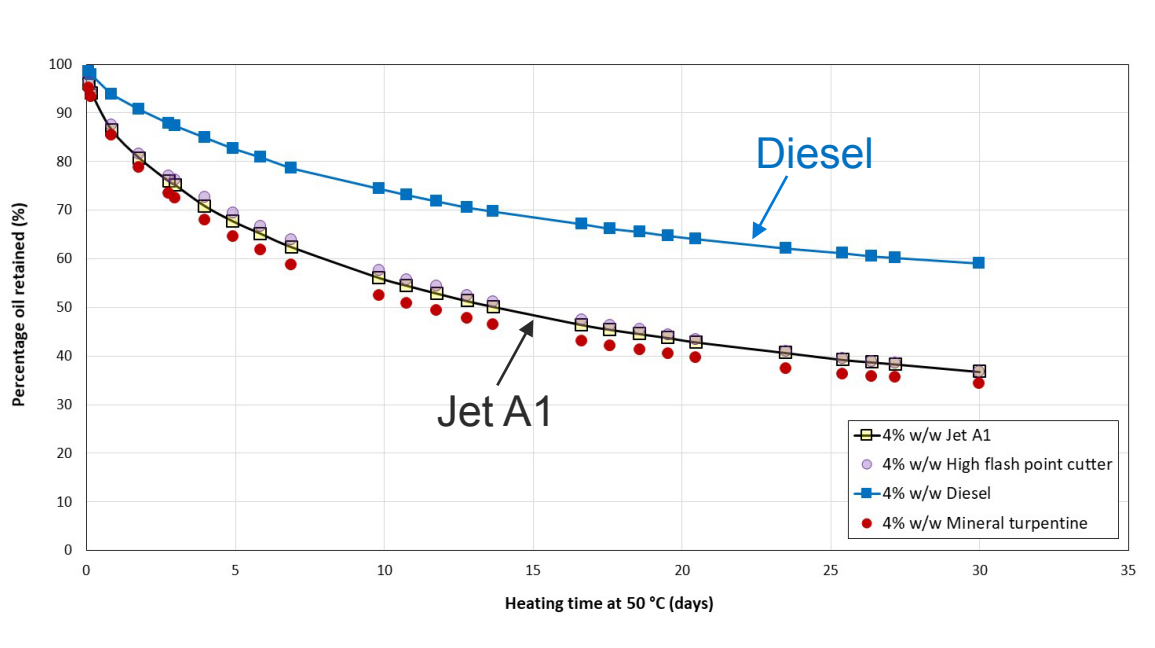
Initial 100% coating results were affected by the concentration of oil in a blend but not the type of oil

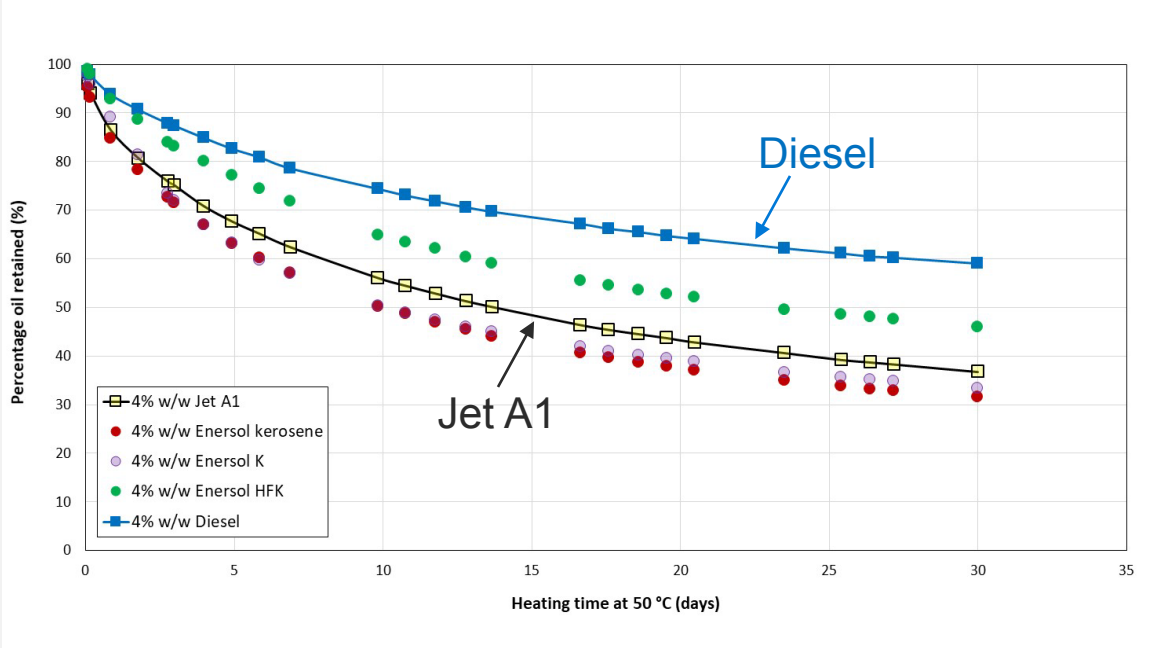
3) Rate of oil loss from sprayed seals

2 mm binder films containing 0, 2, 4 and 6% w/w of each oil

Each binder film was heated for 30 days at either 40, 50 or 60 °C

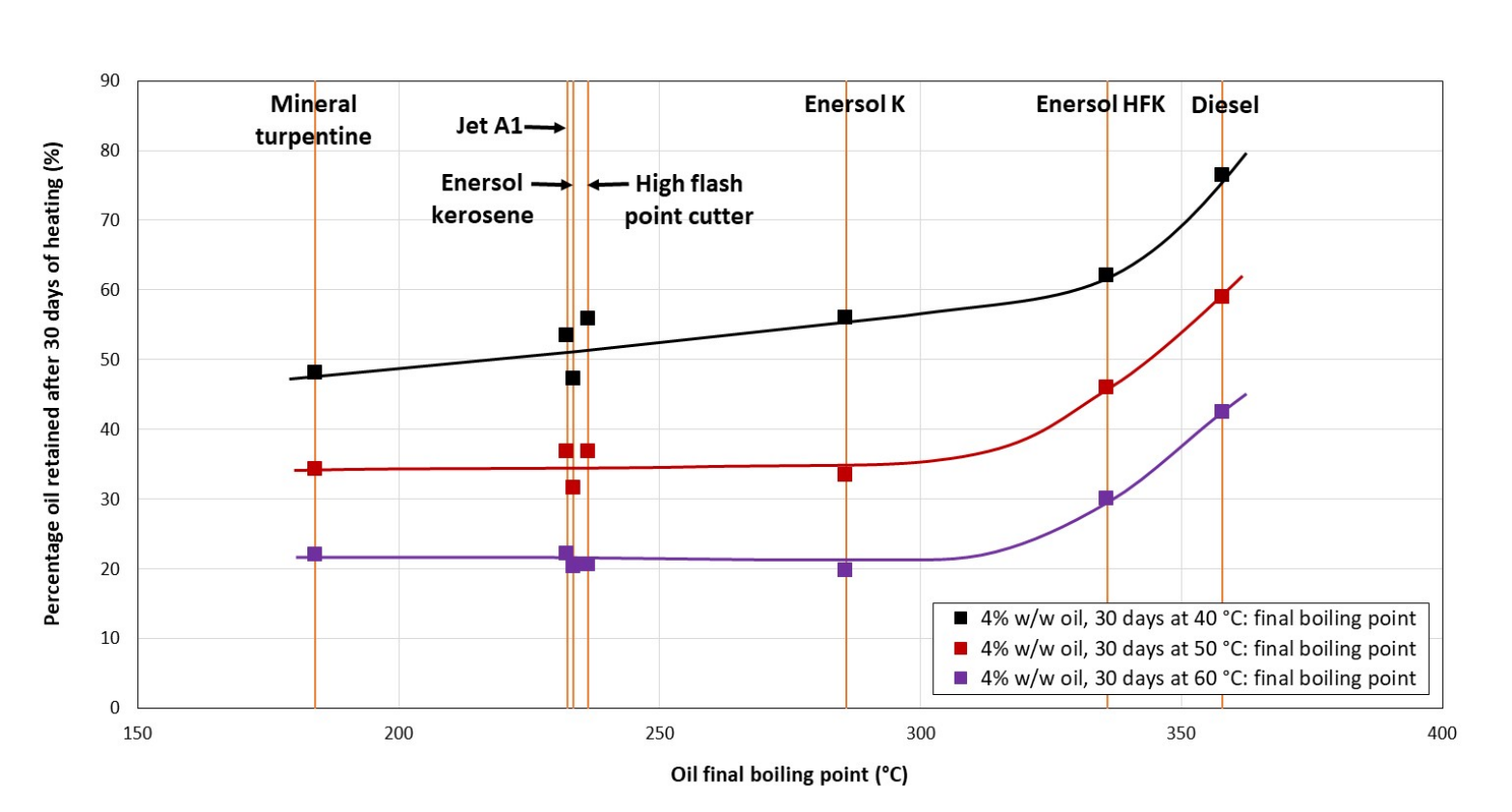
Rate of oil loss from sprayed seals (4% oil at 50 °C)





All binder films except those containing Enersol HFK and diesel showed similar amounts of oil loss after 30 days as those which contained the same concentration of Jet A1

Rate of oil loss from sprayed seals (4% oil at 50 °C)



There was a correlation between the amount of oil lost after 30 days of heating at each temperature and neat oil FBP results

Rate of oil loss from sprayed seals

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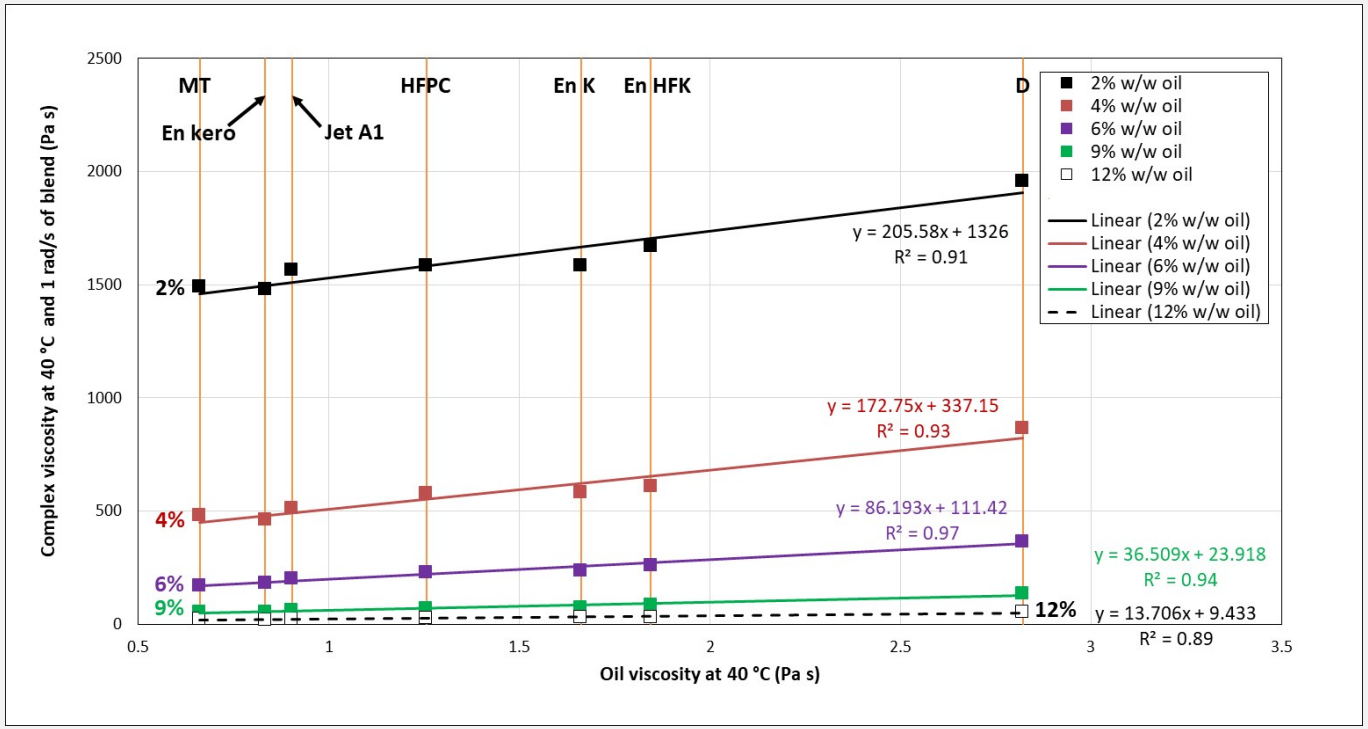
- All oils which had FBP results of < 286 °C showed similar rates of oil loss after 30 days as films which contained the same concentration of Jet A1
- Oils which had FBP results of > 335 °C always showed lower rates of oil loss than films which contained the same concentration of Jet A1
- The FBP specification for Jet A1 is 300 °C max.
- The FBP specification for cutter oil and HFPC has been proposed to be increased to 300 °C max.

4) Effects of using different oils on bitumen viscosity

- The effects of using different oils on bitumen viscosity reduction and AP-T39/05 recommended cutter levels were determined by measuring the complex viscosity (at 1 rad/s) of different bitumen/oil blends
- Blends contained 2, 4, 6, 8, 10 and 12% w/w of each oil
- Tests were conducted at various temperatures between 15 and 65 °C.

Effects of using different oils on bitumen viscosity



The complex viscosity of a bitumen/oil blend was affected by:

- oil concentration
- the viscosity of the neat oil at the test temperature.

Effects of using different oils on AP-T39/05 recommended cutter levels

- An analysis of the complex viscosity results indicated that AP-T39/05 recommended cutter levels were suitable for use if the viscosity at 40 °C of the oil was between 0.5 and 2.0 mPa s, or 0.7 to 2.5 mm^2/s

- These viscosity at 40 °C limits have been proposed for cutter oil and HFPC in a revised version of AS 3568.

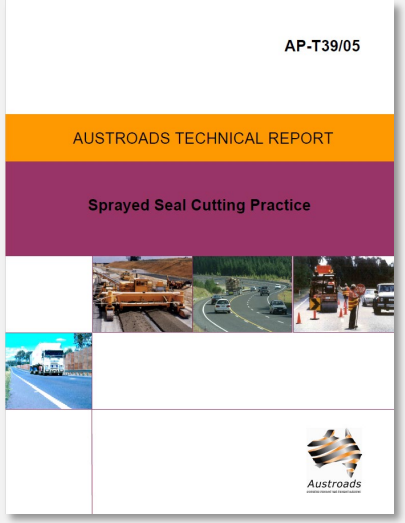


Table 1: Basic Cutting Practice for Class 170 Bitumen

Pavement Temperature (°C)	Traffic (veh/lane/day)	Aggregate nominal size of 10 mm or larger (parts or percentage by volume)	Aggregate nominal size of 7 mm or less (parts or percentage by volume)
20 to 25	<100	8	10
	100 to 1500	6	8
	>1500	4	6
26 to 32	<100	6	8
	100 to 1500	4	6
	>1500	2	4
33 to 38	<100	4	6
	100 to 1500	2	4
	>1500	0	2
39 to 45	<100	2	4
	100 to 1500	0	2
	>1500	0	0
> 45	<100	0	2
	100 to 1500	0	0
	>1500	0	0

Download report at austroads.com.au/publications/pavement/ap-t39-05

Performance-based oil properties

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- The main factors that appear to effect the performance on an oil in a sprayed seal are:
  - Oil final boiling point (FBP) → rate of oil loss from a seal
  - Oil viscosity at 40 °C → bitumen viscosity reduction

- Oil aniline point and aromatic content: no correlation with performance → proposed to be removed from AS 3568
- All oils were miscible with bitumen → include a general miscibility requirement statement in AS 3568.

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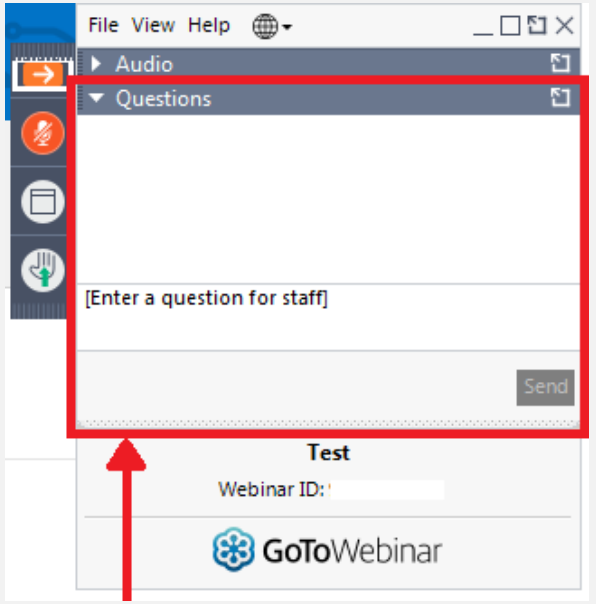

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Proposed Revisions to AS 3568

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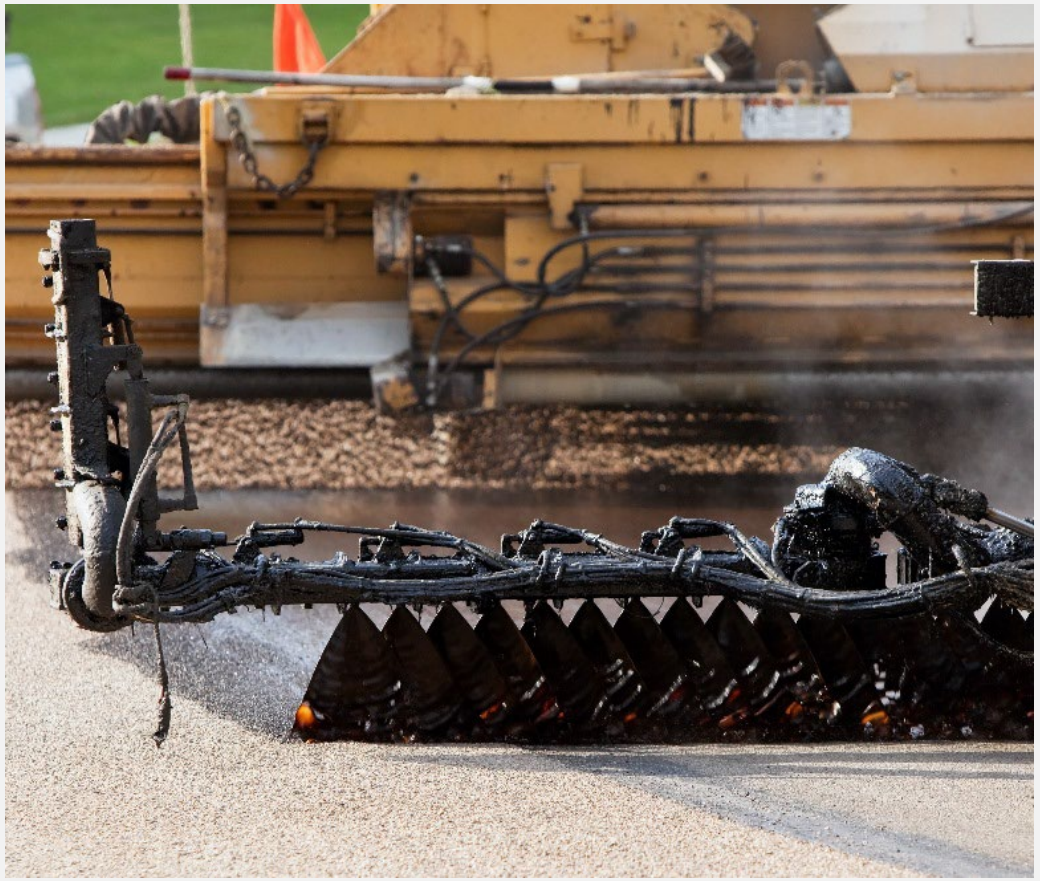
Working Group agreed changes to AS 3568

- Change the requirements for flux oil to meet the requirements for automotive diesel fuel
- Remove heavy flux oil
- Allow certified Jet A1 to be also used as cutter oil
- Change density at 15 °C requirements for cutter oil and HFPC cutter to ‘report’.



Other proposed changes to AS 3568

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- Replace current requirements for fluidity (liquid, clean and free of particulate matter) and water content (0.1% by volume max.) by a visual appearance requirement:

  Clean, bright and visually free from solid matter and dissolved water at ambient temperature

- The test methods for flash point and density at 15 °C have been updated.

Proposed specification table for cutter oil and HPFC

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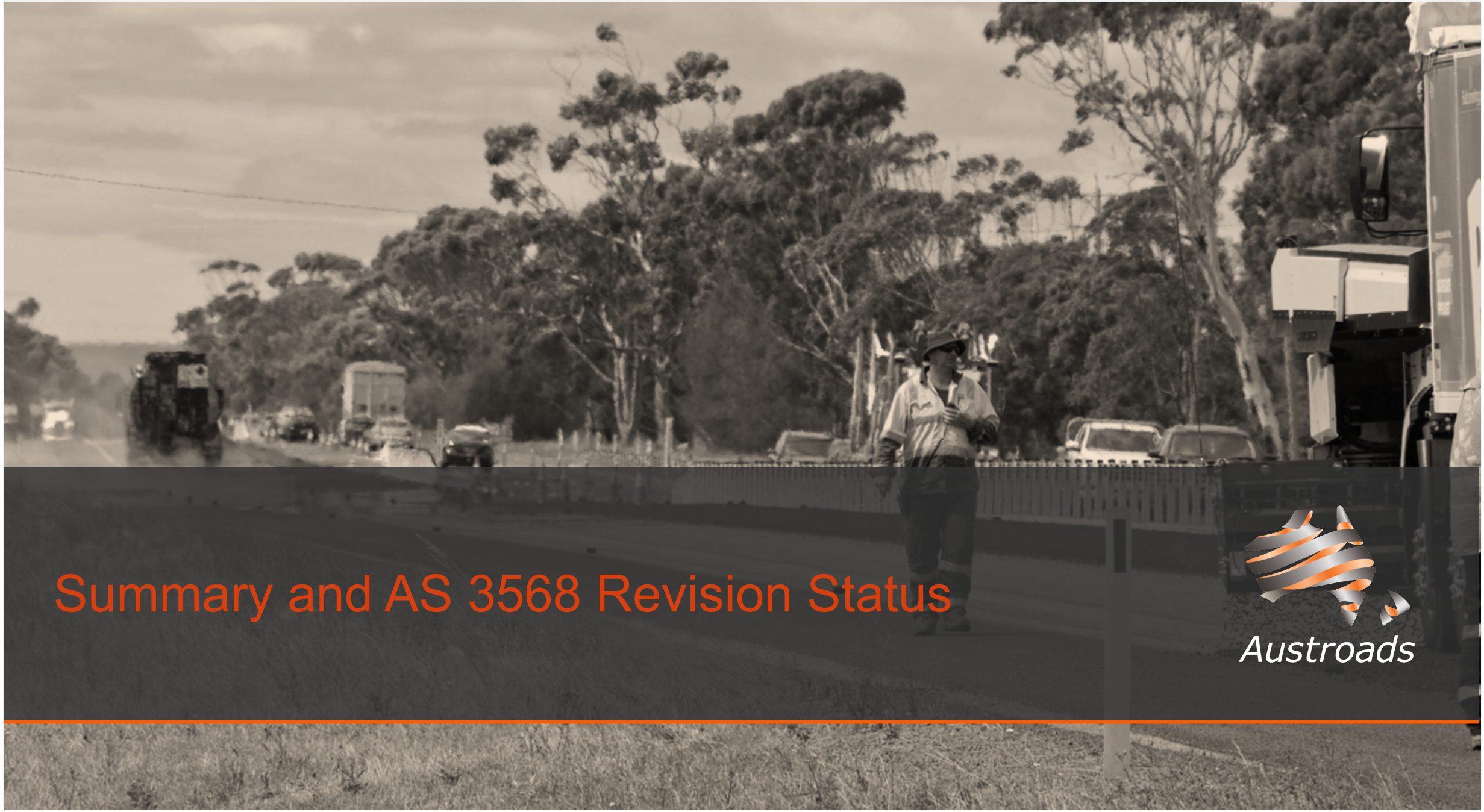
Property	Requirement				Method of test
	Cutter oil (1)		High flash point cutter		
	Min.	Max.	Min.	Max.	
Appearance	Clean, bright and visually free from solid matter and undissolved water at ambient temperature				–
Flash point (°C)	38	–	61.5	–	AS/NZS 2106.1 or AS 2106.2 or ASTM D93 or ASTM D3828 (2)
Distillation range IBP (°C) FBP (°C)	 140 –	 – 300	 140 –	 – 300	ASTM D86
Viscosity at 40 °C (mPa s) or Viscosity at 40 °C (mm^2/s) (3)	0.5 (4) 0.7 (5)	2.0 (4) 2.5 (5)	0.5 (4) 0.7 (5)	2.0 (4) 2.5 (5)	ASTM D445 (6)
Density at 15 °C (kg/m^3)	Report				ASTM D1298 or ASTM D4052

(1) Oils which have been certified to meet the requirements of Jet A1 aviation fuel may also be used as cutter oil.
(2) Flash point tests shall be conducted using the method of test applicable to the flash point result obtained for the sample being tested.

Notes (3) to (6) relate to reporting Viscosity at 40°C test results in either dynamic viscosity units (i.e. mPa s) or kinematic viscosity units (i.e. mm^2/s) as required by the purchaser.



Summary and AS 3568 Revision Status

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Summary and AS 3568 revision status

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- During the study 7 commercially available oils were subjected to 4 different laboratory performance tests
- The main factors which affected sprayed seal performance were oil FBP and viscosity at 40 °C
- Proposed changes to AS 3568 include:

Cutter oil	HFPC	Flux oil	Heavy flux oil
Revised AS 3568 specification table developed focussing on performance-based properties		Meets requirements of automotive diesel fuel	Removed from AS 3568

- Standards Australia approved a project proposal to update AS 3568 on 14/11/18.

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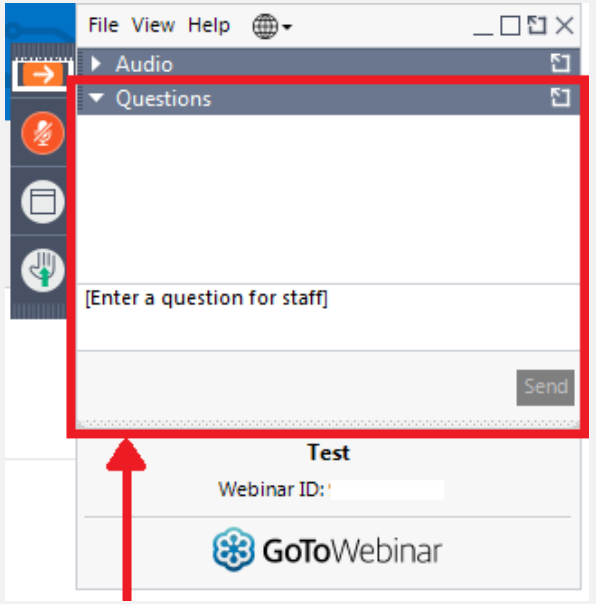

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Questions?

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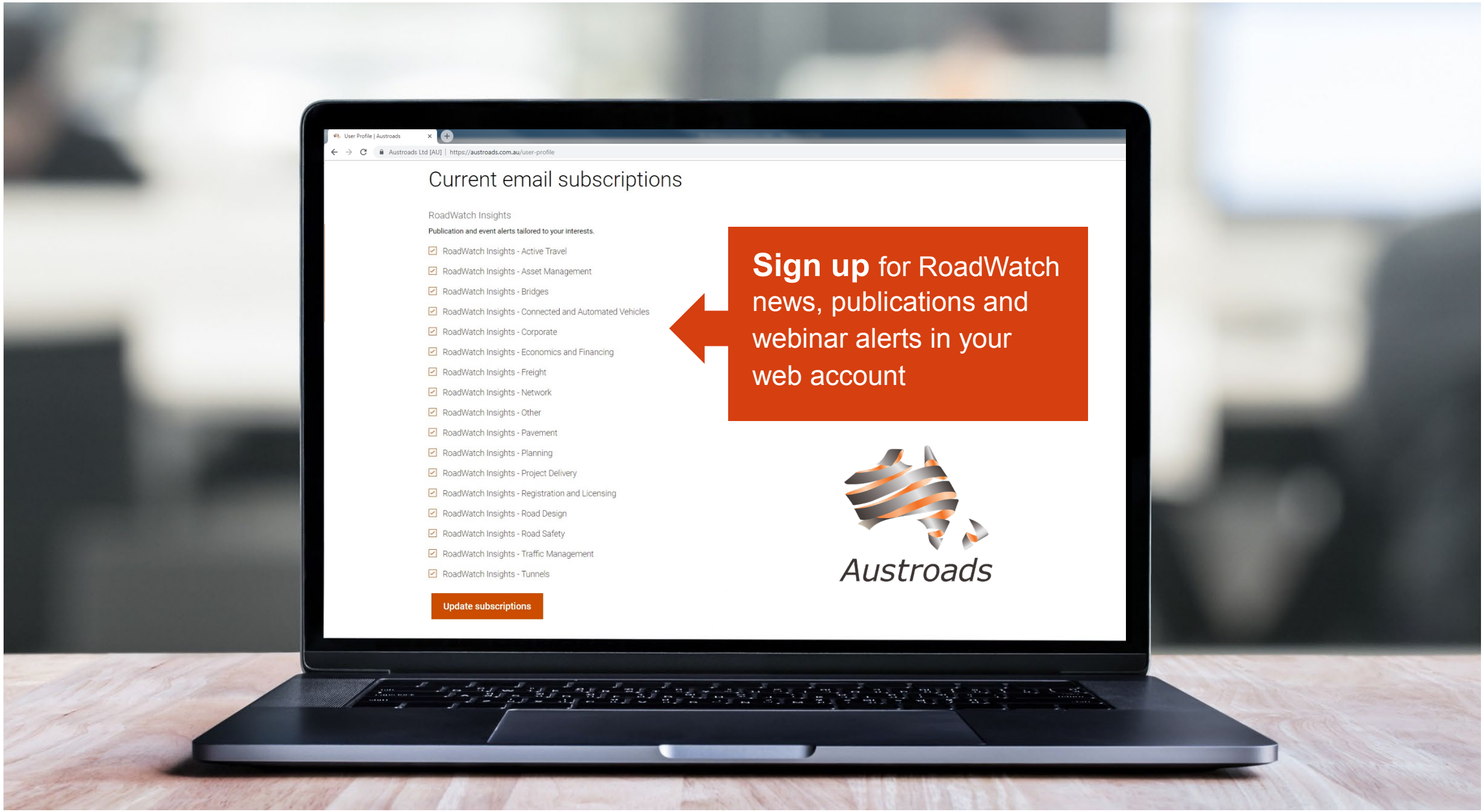
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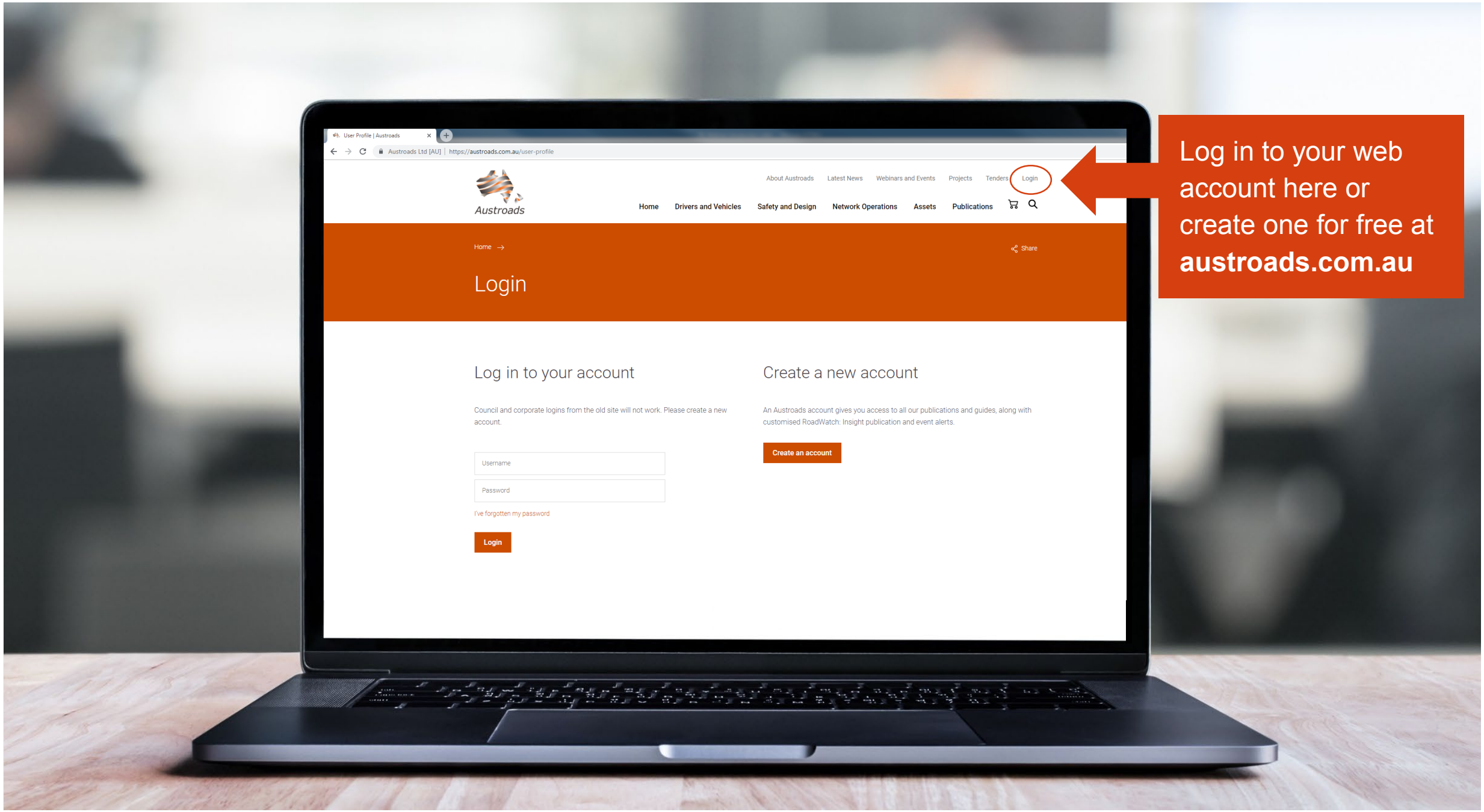

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