SIRIS CORP. (AUST.) PTY. LTD.

Investigation of Ultraseal® Tyre Sealants

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Introduction and Summary of Investigations & Findings

SIRIS Corporation (Aust) Pty Ltd (henceforth referred to in this report as "the firm") was approached by Ultraseal Australia (henceforth referred to in this report as "the client") and requested to utilize a series of technical reports commissioned by Ultraseal and conducted by highly reputable sources in accredited facilities to:

1) Discuss the chemical composition and mechanism of action of Ultraseal (henceforth referred to in this report as "the product" or by name) on tyres.

2) Discuss the effects of Ultraseal on tyres.

3) To establish what claims can be made of the product that are supported by the scientific evidence.

4) To review an ATMA statement issued in October 1989 and to compare statements made with scientific evidence and issue a technical opinion on the statements issued.

Recommendations Arising From this Investigation

This study finds that Ultraseal provides a clear and demonstrateable advantage for its users. Please refer to the relevant sections of this report for the technical basis for this statement. There is no evidence of chemical incompatibility of the materials in the product to the components of tyres. It is noted that a study to confirm this is recommended. It is the current opinion of the firm, that the ATMA findings are not based on scientific evidence but rather, would appear to be comments issued as a result of a "round-table discussion" of industry experts. The opinions stated in the ATMA document are plausible and reasonable on first inspection, however, data presented in the technical reports supplied to the firm and commissioned by the client (and not available to the ATMA at the time they issued their statement) would suggest that the some of the statements and the conclusion arising thereof, are not sound.

Disclaimer:

- It should be clearly noted by all, that SIRIS Corporation (Aust) Pty Ltd is an independent organization and whilst being contracted by the client, remains neutral and objective in its investigation and findings. As such, it can neither endorse nor advocate the product. All statements made are based on evidence as presented to the firm by technical reports from sources that to the best knowledge of the firm are reliable and accredited. No section of the report to be issued should be taken out of context.

Sample Description

Sample Number	Date Received	Description.
Document 97-07-001	18-7-97	1. Bridgestone Australia Ltd Technical Service Bulletin dated 16-2-90 2. Australian Tyre Manufacturer's Association Public Statement dated October 1989 3. Ultraseal ® Product Overview Compiled and Presented by Mervyn Sher, Ultraseal Australia 4. Ultraseal ® Material Safety Data Sheet dated 10-3-93 5. Dr Jaako Tae Specifications for Tire Sealant dated 21-7-82 ASTM test No. D92
Document 97-07-002	18-7-97	1. Test Report 361/82080/F884 dated 17-11-89 Tyre Sealant Flash Point by ASTM D92-85: testing and report conducted by South African Bureau of Standards, Pretoria 2. Test Report 321/85179/C224 dated 19-2-90 Smoke Toxicity Index: testing and report conducted by South African Bureau of Standards, Pretoria 3. Test Report 361/82157/G125 dated 12-3-90 Density by IP 190/86: testing and report conducted by South African Bureau of Standards, Pretoria 4. Test Report 361/82157/G125A dated 27-3-90 Stability under centrifugal forces: testing and report conducted by South African Bureau of Standards, Pretoria 5. Test Report dated 23-7-96 Field testing for 2½ years on fleet of Carstensen Freight Lines, Inc: testing and report by Bundini Corporation (USA), Florida. 6. Test Report dated 13-9-91 Short term Field testing on fleet of Carstensen Freight Lines, Inc: testing and report by Bundini Corporation (USA), Florida. 7. Test Report dated 22-10-76 Laboratory Testing of Sealant and effects on Tire and Rim: testing and report by Smithers Transportation Test Center, Smithers Scientific Services, Inc, Ohio 8. Test Report dated 27-4-92 Light Truck Treadwear Test: testing and report by Smithers Transportation Test Center, Smithers Scientific Services, Inc, Ohio 9. Faxed Report dated 26-5-92 Physical Testing on tires post wear test: testing and report by Smithers Transportation Test Center, Smithers Scientific Services, Inc, Ohio 10. Test Report dated 21-5-92 Physical Testing on tires post wear test: testing and report by Smithers Transportation Test Center, Smithers Scientific Services, Inc, Ohio 11. Faxed Report dated 15-6-92 Air Permeation of Inner Liner: testing and report by Smithers Transportation Test Center, Smithers Scientific Services, Inc, Ohio 12. Test Report dated 26-5-77 Ref: SPC/1 Test summary for test programs by Ultraseal International: report by Asiatic Petroleum Corp. (a division of Shell Laboratories), New York

Sample Description Continuation ...

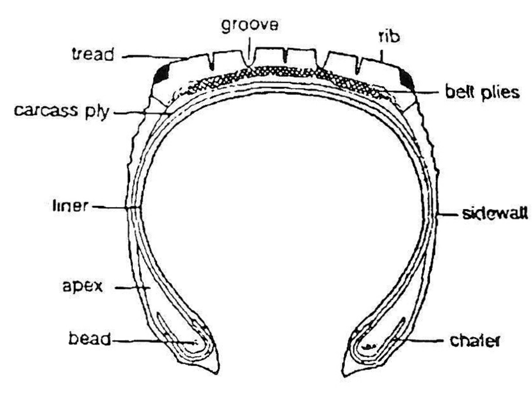
Sample Number	Date Received	Description.
Document 97-07-002	18-7-97	13. Test Report DTTR.0012.75 dated November 1975 Evaluation of Tyre Sealant Ultra-Seal: testing and report by Shell Research, The Hague 14. Test Report - Cycle Products Research Study #2461.5-TBT dated 19-6-80 testing of Ultraseal on Motorcycles: testing and report by Cycle Products Research, California 15. Test Report ME89/72 dated 15-9-89 Toxicity Index Tests on Ultraseal Tyre Sealants: testing and report conducted by Genmin Laboratories, Materials Engineering, South African Bureau of Standards, Pretoria 16. Test Report 653/81976/F3191 dated 12-5-89 Toxicity Index: testing and report conducted by South African Bureau of Standards, Pretoria 17. Test Report 653/81976/F3191 dated 22-11-89 Toxicity Index: testing and report conducted by South African Bureau of Standards, Pretoria 18. Test Report dated 3-7-89 Ultraseal Pumps: testing and report conducted by South African Bureau of Standards, Pretoria 19. Test Report 361/82080/F884A dated 11-12-89 Tyre Sealant as per Dr Jaakko Tae Specifications: testing and report conducted by South African Bureau of Standards, Pretoria

Basic Concepts in Tyre Technology

It is not the purpose of this report to give detailed information as to the formulation of rubbers and other materials used in tyre construction. This section is a brief overview of the area presented as an aide to readers outside of this industry in appreciating the relevance of the information to be highlighted thereafter in relation to tyre sealants. This section is highly generalized and does not purport to represent any given make or specific model. It is generic information with reasonable applicability to most models in production and sales.

Tyre terminology

Figure 1 below gives a generalized view of the major components in tyres.



1) The **Carcass** consists of plies made up of many high modulus cords embedded in a rubber matrix

2) The carcass plies are turned around **beads** located close to the rim flanges. The beads anchor the carcass plies and hold the assembly to the wheel rim.

3) The **tread** is the part of the tyre that contacts the road surface. It protects the carcass and provides the frictional contact used to transmit driving, braking, and cornering surfaces.

4) **Belts** are fibre-reinforced composite plies forming a hoop under the tread. They restrict deformations of the carcass plies and provide added stiffness to the tread.

5) **Chafers** are strips placed along the outside of the beads and plies to protect the carcass plies from cutting and wearing. To provide improved tyre-rim contact pressure distribution, and to prevent moisture and dirt from penetrating into the tyre.

6) **Innertubes** are flexible closed toroidal balloon structures placed to contain pressurized air in tube-type tyres.

7) In a tubeless tyre an airtight seal is formed between a compression fitting and sliding the tyre bead on an inclined rim. Additionally these tyres have an **inner lining** (which is typically a thin layer of low permeability butyl rubber molded inside the tyre to reduce air loss).

8) The portion between the tread and beads is the **sidewalls**. They support the tread region and protect the carcass from damage. They also are chiefly responsible for the tyre's ride characteristics. As with other parts of the tyre the rubber formulations here are fundamentally different from the other components.

9) The junction area of the tread and sidewalls are called **tyre shoulders**.

10) The point at the centre of tread section, midway between the shoulders is the **crown**.

Basic Tyre Construction Types

Figure 2 (below) shows a schematic of a **bias tyre**. This type has the body chords making a large angle with the centre treadline and there are no belt plies in the tread region.

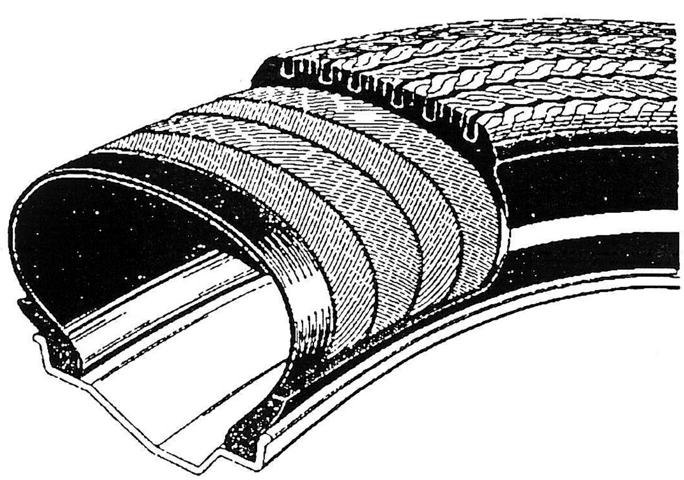


Figure 3 (below) shows a schematic of a **bias-belted tyre**. This type is similar to bias tyres but in addition to the basic body plies, have two or more belts between the tread and the carcass.

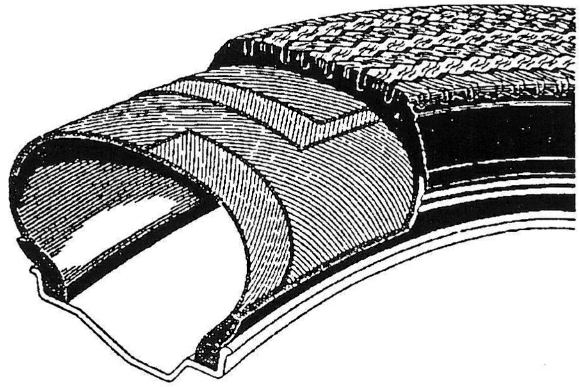
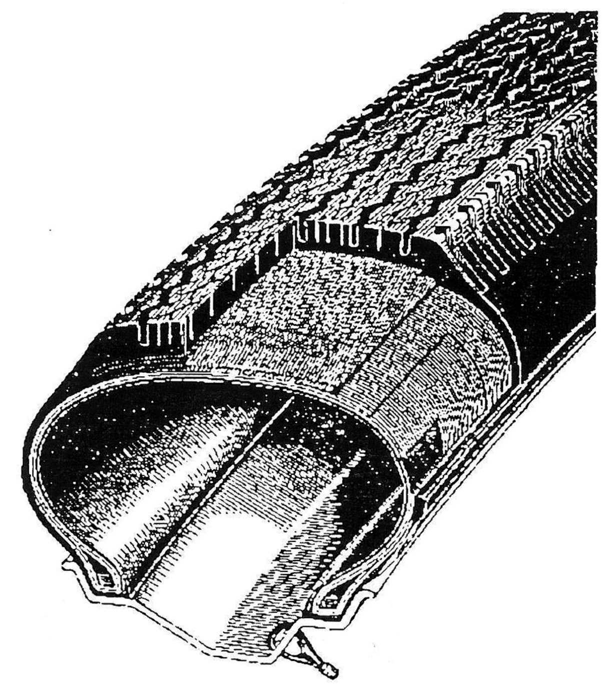


Figure 4 (below) shows a schematic of a **radial tyre**. This type are also belted, but they have carcass cords that lie perpendicular to the circumferential direction. The radial orientation of the belts results in very flexible sidewalls, which act independently of the belts giving lower tread movement in the footprint than bias belted tyres.



Cast tyres contain no fabric, only elastomers to form the air chamber and bead wires for anchoring to the rim.

Belt construction and configurations types

Figure 5 (below) shows schematic examples of some steel cord configurations whilst figure 6 (below) shows examples of bead wire configurations. This area, although relevant to a degree to the issues of tyre punctures and ruptures is out of the specific scope of this basic introduction.

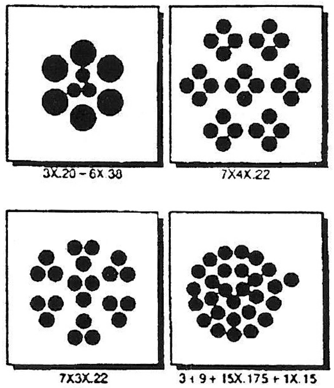


Figure 5

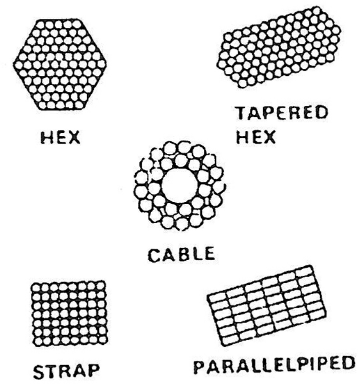


Figure 6

Materials used in tyre construction

Tyre compounds are mixtures of materials such as elastomers, carbon black, and/or silica plus a cure system. Other ingredients are added to aid the process, to develop specific properties or to provide compound stability. It is beyond the scope of this report to outline the theory and practice of material formulations. During production high speed pressure loaded sheering mixers (called Banburys) sheer the carbon black particles into the elastomer forming bound rubber. The mixing requires several stages to reduce the thermal degradation of the elastomer chains. Once dispersed sufficiently, the other ingredients are dispersed or melted into the mix and the curatives are added in a short lower temperature final mix.

The list of possible ingredients that could be utilized in these formulations are quite extensive and include aluminium powder, aluminium silicate, ammonium bicarbonate, antimony sulfide, antimony trioxide, asphalt, barytes, bentonite, bitumen, blanc fixe, butyl rubber, cadmiun yellow (sulfide), cadmium oxide, cadmium red/cadmium selenide, calcium carbonate, calcium silicate, carbon black, carnuaba wax, castor oil, ceresin wax, clay, ground cork, cotton flock, cottonseed oil, diatomaceous earth, dibutyl amine, dibutyl phthalate, diethylene glycol, dibutyl sebacate, dolomite, factice, french chalk (talc), gelatin, glue (bone), graphite flakes, ground glass, gypsum, iron oxide (red), kaolin, kerosene, kieselguhr, koresin, lanolin, lauric acid,lead dioxide, lead sulfate, hydrated lime, litharge, lithopone, magnesia LC, magnesium carbonate, powdered mica, mineral rubber, mineral oil, natural rubber (several different types and sources), neoprene, nitrile rubber, oleic acid, ozokerite wax, palm oil, paraffin wax, petrolatum, pine oil, pine pitch, polyisoprene, rosin, salicyclic acid, styrene-butadiene rubber, shellac, silica, soapstone, sodium acetate, sodium acetate trihydrate, sodium bicarbonate, stearic acid, sulfur, talc, titanium dioxide (anatase), titanium dioxide (rutile), tricresyl phosphate, trietholamine, ultramarine blue, urea, vaseline, vermilion (mercury sulfide), gilder's whiting, whiting (ground limestone), wood flour, zinc carbonate, zinc oxide, zinc stearate, & zinc sulfide. Added to these there are a vast number of specialty additives which can be added into the formulation.

Tyre compounds (as with most rubber formulations) are usually (but not always) defined based on 100 parts of rubber hydrocarbon. Below are some typical generic formulations (these are not intended to represent the formulations of any particular manufacturer nor model and are for illustrative purposes only).

Element or Compound	Passenger tread	heavy-duty sidewall	ply coat	apex
natural rubber		60	60	75
SBR (styrene butadiene rubber)	75		40	25
polybutadiene	25	40		
carbon black	75	60	60	80
zinc oxide	3.0	3.0	3.0	5.0
stearic acid	2.0	2.0	2.0	2.0
wax	1.0	2.0		
process oil	40	5.0	5.0	10
tackifier		2.0	3.0	5.0
antioxidant	1.0	1.0	1.0	1.5
antiozonate	1.5	3.0		
bonding resin			3.0	
sulfur	2.0	3.0	2.5	3.0
N-cyclohexyl-2-benzothiazole sulfenamide	1.6	1.0	1.4	1.4
PVI	0.2	0.2	0.2	0.3
	227.3	182.2	181.1	208.2

Whilst it is not the intention to highlight rubber technology, the issue of cure is an important one and warrants a small discussion. Rubber exists in a bulk state as high molecular weight polymer chains similar to spaghetti. Many of the chains are entangled. However when stress is applied some of the chains can slide past each other and become unentangled. Elastomers used in tyre formulations generally contain unsaturation in the form of double bonds that permit curing or crosslinking. The addition of carbon black with the development of bound rubber and chemical crosslinks produces locks bewteen chains. Because of these crosslinks the compound is considered to be thermoset. The sulfur crosslinks in the compound are permanant, but slowly they change to polysulfidic to disulfidic to monosulfidic with service life. Another relevant bonding is related to crystallinity. Above the melting point of the crystalinne structure, the polymer flows more freely, below the melting point it is more rigid. Crystallinity enhances tear resistance, flex fatigue, and hysteresis. Natural rubber has some capability to crystallise because of the regular structure of its polymer chains hence it is usually included in formulations.

Other important and relevant are silica reinforcement which improve tear resistance with less heat buildup than carbon black. There are a multitude of issues here that are out of the scope of this report. The other highly relevant area that requires some introduction, is the compound cure system. There are many ways to crosslink the unsaturated double bonds and a few systems to form carbon-carbon crosslinks (eg using peroxides or resin cure). However, in tyre manufacture the predominant form features both soluble and insoluble sulfur and accelerator systems. Zinc oxide and fatty acids are used as cure activators and retarders are used to improve safety or delay cure in manufacture for various reasons. Accelerators fall into eight major types: thiazole, sulfenamide, dithiocarbamates, triazine, thiuram, xanthate, guanadines, and thiourea types. The tyre cure is a very simple operation but a very complex chemical process. The tyre cure rates are restricted mostly due to poor heat transfer rates of the compounds. Also natural rubber compounds tend to revert at higher temperatures; that is they lose stiffness as a result of elastomer scission. Synthetic compounds tend to become stiffer at higher temperatures and longer cure times. Hence to manufacture a tyre to optimum requires careful control of the curing. The simplicity of the operation may on occassion leads to complacency with a situation of under-cure or over-cure. As a general rule only, undercured tyres are softer and wear out faster, overcured tyres are more brittle and may lead to flex fatigue.

Reinforcement with organic or steel cords is vital to the performance and durability of a tyre. Organic fibres are dipped in an isocyanate and/or a system based resorcinol-formaldehyde latex (RFL). The dipped fabric is then heat treated. Rayon, nylon, polyester, polyvinyl alcohol and polyamide cords all require some form of dip to bond to the compound. Both steel cord and bead wire feature alloy coatings that facilitate drawing and bonding to rubber. Specific brass coatings are used exclusively on steel cord and only on some bead wire. The brass layer and the gradient composition are very important to the initial adhesion and to the service life of the rubber-brass bond. There are intermediate zinc sulfide and copper sulfide layers that critically affect the mechanical adhesion of the rubber to the cord. The cure system is also vital to the development of bonds to steel cord that can withstand air and moisture, road salt corrosion and the heat experienced during the life of the tyre. An improper cure system or a faulty rubber-brass bond due to imbalance of cobalt salts (chelating agents used to regulate layer formation), sulfur levels, zinc oxide or fatty acid grades can lead to "delamination". This is where the rubber peels off from the steel cords, eventually leading to splits in the rubber and the consequential tyre failure.

Ultraseal® Properties and Possible Mechanism of Action

Disclaimer: The firm was not supplied by the client, sufficient formulation details nor laboratory evidence as to the mechanism of action of Ultraseal® The following is based on documentation provided and a reasonable estimate of some parameters. It should be very clearly noted that this is **speculative** in nature and would require laboratory studies to either confirm or refute these hypotheses. These hypotheses are being utilized to give reasonable estimates as to possible mechanisms which explain the observed functionality of the product. The next section will itemize the claims that can be legitimately made of the product based on scientific evidence.

Approximate formulation (it is clear several important ingredients are missing presumably, to protect proprietary interests):

Compound/Material	Approximate Weight
Ethylene Glycol	10-30
Potassium Chromate Sulfate	< 0.1
Water	60-70
Inert Solid Fillers	10-20

It is the firm's understanding that Ultraseal® is injected by means of high pressure short burst devices into inflated tyres that have been pre-balanced and driven for short periods. The material exists as a blue viscous liquid with some gelling properties. It appears to have small rubber-like material suspended within it and some small white particulates. It consists of very fine fibres distributed in a water based adhesive (ref: 97-07-002—13). There needs to be sufficient amount injected to allow a thick film formation over the entire inner surface - distributed by the centrifugal forces of the tyre during motion.

This material will collect as a sump at the bottom of the tyre but have some residual film over the entire inner tyre. It will also be expected to exist in equilibrium at any given temperature with the water evaporating or condensing with associated shifts in partial vapour pressures and temperatures.

The possibility of catalytic content is unknown at this point, but it is presumed that a possibility exists for the material to partially react and/or form fibrolytic clots. This point is purely **speculative** as the MSDS does not report the identity of the inert fillers which may be clay, talc, carbonates, etc. or resins or other material that may allow crosslinking with rubber chains. No experimentation has been conducted to establish the identities of the materials present and thus it is not possible at this stage to speculate further. Another possible mechanism of action is that the material acts as a air tight film that is forced against the puncturing object to form an air-tight seal. When this material dislodges the product is partially expelled and reactions with the external environment to form a polymeric material that may adhere to the tear and strengthen the damaged site within the tyre. These speculations should be investigated by scientific experimentation and observation/measurements before a suggested mechanism is exposed to be the actual operating mechanism.

There is no information that would suggest the incompatibility of the Ultraseal® components with the tyre inner lining. The next section which deals with the claims that are supported by scientific evidence would give some indirect measure that an incompatibility is unlikely.

Ultraseal® Properties as Evidenced by Scientific Investigations

Disclaimer: The firm was supplied by the client technical reports as outlined in the sample description table (pages 2-3). These reports detail laboratory and field research evidence as to various studied aspects of Ultraseal® The following is based on this documentation and provides data from these sources or calculated results based wholly on the figures as supplied. Please note that the units have been converted to Australian equivalents e.g. mph → km/hr, °F → °C, etc The dimensions of nails have been left in imperial as this is a common description form in Australia for these items. Where possible, comparisons are made with compliance to Australian Standards (where such standards exist).

General properties of Ultraseal®

Reference	Ultraseal® Grade	Flash Point °C
97-07-002-1	Mining grade	> 96
97-07-002-1	Commercial grade	> 84

Reference	Ultraseal® Grade	Smoke toxicity (toxicity index)
97-07-002-2	Mining grade	low (1.1)
97-07-002-2	Commercial grade	low (1.3)

Reference	Ultraseal® Grade	Separation %(v/v) @ 60°C
97-07-002-19	Mining grade	< 1
97-07-002-19	Commercial grade	< 1

Reference	Ultraseal® Grade	pH
97-07-002-19	Mining grade	8.5
97-07-002-19	Commercial grade	8.6

Reference	Ultraseal® Grade	Viscosity (cp) @ 20°C
97-07-002-19	Mining grade	6
97-07-002-19	Commercial grade	5

notes: The viscosity of water @ 20 °C is 1.002 centipoise (cp). The reference reports in units of Pascal-second (Pa.s) These have been converted to centipoise equivalents).

Reference	Ultraseal® Grade	Cold Stability @ -18°C
97-07-002-19	Mining grade	not frozen
97-07-002-19	Commercial grade	not frozen

Reference	Test on Ultraseal®	Result
97-07-002-3	density @ 20°C	1.0715 g/ml
97-07-002-4	*separation @ 250km/hr	7 %v/v

notes: * Ultraseal® was tested in the laboratory with centrifugal forces equivalent to a tyre with outside diameter of 1072mm travelling at a speed of 250 km/hr. The rubber like materials and white particulates were forced to collect at what is the equivalent of the tyre liner and were estimated at 7 %v/v. The gel component appeared unchanged.

Sealing ability: Michelin XCHA LT215/85R16 with Ultraseal® were tested against controls from the same batch without Ultraseal® (reference 97-07-002-7). 12 radial and 12 belted bias tyres were tested for efficacy of Ultraseal® at two temperatures (-12 °C and 38 °C) with nails (0.10" dia. X 2-1/8" long) and cuts (1/8"dia. and ¼" long) and at a speed of 80 km/hr. Theses were run in at 1,112 km then had Ultraseal® added, then ran for another 1,568 km and then nails were hammered into the center of the tread. The vehicle was run for a short period and the tyre was observed to see if a seal had occurred. The inflation pressure was re-adjusted to nominal if warranted and then observed for two days to see if any loss on standing. The tyres were then run on test vehicles for an additional 65,980 km approximately. The air pressure remained nominal and the air pressure was not adjusted during the final test from 1,127 km approx. to 66,788 km approx. demonstrating the long-term effectiveness of the seal.

Tested Tyre Properties:

Reference:	Property	New Tyre	Control/worn	Ultraseal®/worn
97-07-002-7	* average mileage (km)	n/a	76,853	78,177
97-07-002-7	* mileage variability (km)	n/a	7,108	2,503
97-07-002-9	Shore Hardness	55	54	54
97-07-002-9	Tyre Tensile Strength (psi)	1680	1475	1450
97-07-002-9	Tyre Elongation (%)	780	710	685
97-07-002-9	Cord Tensile Strength (psi)	47.5	46.3	46.9
97-07-002-9	Cord Elongation (%)	33.6	29.3	30.8
97-07-002-11	** Mean Air Permeability	not tested	1.76	2.07
97-07-002-11	** Variability of Air Permeability	not tested	0.23	0.09

notes: Test tyres Michelin XCHA LT215/85R16 load 1,059 kg, inflation 65 psi
* Defined as mileage to 62.5 mil wearbar.
** Calculations by the firm based on raw data provided in reference 97-07-002-11 show a 15% improvement in air permeability, ref:97-07-002-11 claims 10% improvement.

Field Tests: Ultraseal® was field tested for 2.5 years (reference 97-07-002-5) on Goodyear G167A 11 R 22.5 tyres fitted to both front and rear axles on tandem tractors. During internal tyre and wheel inspections (well over 161,000 km) no evidence of rust or corrosion was found. The Ultraseal® appeared to have been stable. There were no vehicle downtime due to tyre-related problems with the tyres fitted with Ultraseal®. The averaged longevity of the tyres fitted with Ultraseal® was improved by 24% by comparison with controls.

Dynamic tyre balance is improved by Ultraseal® (reference 97-07-002-12) however the static balance is affected, hence a tyre rim assembly must be in balance prior to Ultraseal® being installed. Tyre performance (as measured on indoor dynamometer) is not affected (reference 97-07-002-12).

What do these results mean?

The flash point indicates that this material won't self-ignite at elevated temperatures. The test report (reference 97-07-002-1) remarked that the products boiled at these temperatures but did not ignite. Further more, if the tyre was to catch fire, then the smoke toxicity indicates that it is reasonable to claim that far more irritation would be produced by the combustion products of the tyre rubber than from the small amount of Ultraseal®. Furthermore, the materials liberated during such a fire by Ultraseal® have an overall low toxicity and consist mainly of small quantities of carbon monoxide and nitrogen oxides.

The separation data indicates that if you leave your car such that the internal temperature of the tyre reaches 60 °C (e.g. parked such that the tyres are in direct sunlight on a hot day), there is no effect on Ultraseal's ® gel form. The cold stability data indicates that if you take your car and park it in the snow (it is highly unlikely that the temperature within the tyre will reach below -18°C), Ultraseal® has been tested (to -18°C) and verified not to freeze. The separation at 250 km/hr data shows that at high speed the rubber-like components of Ultraseal® are forced to form a layer on the tyre liner. The gel however appears unchanged at these speeds. This finding is consistent with the suggestion that when a puncture occurs either an airtight film will form around the embedded object or should it dislodge, the escaping air would be likely to drag these rubber-like materials into the void along with the gel material.

The density of this material is approximately the same as water but it is 5-6 times more viscous. Its pH indicates that it is mildly caustic and is possibly as such an irritant, to sensitive hands. If an operator is known to have skin that is sensitive to alkaline materials then suitable precautions should be taken such as appropriate protective articles.

There are two Australian Standards pertaining to new tyre for motor vehicles. AS2231-1980 (New Tyres For Passenger Cars) and AS2230-1990 (Pneumatic Tyres - Light truck and truck/bus - new). These standards refer to compliance with the technical requirements of ADR 23. As best as can be gauged from the documentation, the tyres tested overseas would have complied with the appropriate Australian Standards.

In laboratory settings (which measured to defined end-points), the average mileage showed that the tread lasted approximately 2% longer on Ultraseal® fitted tyres than the same tyres without Ultraseal®. In actual trials on fleets on the road, this figure appears much larger (see next page) because the tyre life was measured in actual practice as opposed to measuring the wear on the tread. In the same laboratory study/trial that showed a 2% increase in tread-life, the mileage variability showed that their was less difference in the wear on a group of tyres fitted with Ultraseal®, hence the group of tyres are more likely to evenly wear. Thus at changeover there will be little difference between the least and most worn out and they are more likely to be swapped over as a group than individually.

The shore hardness, tensile strength and elongation of the tyre, are measures of the "cure". That means to say, they give a good indication if the tyre was "cooked" (as per the recipe) properly. They indicate how elastic or brittle, the relative likelihood of withstanding a foreign object and how soft or hard a rubber is. The figures show that on these tyres, Ultraseal® had no effect whatsoever on these figures. The figures show that compared to a new tyre both the treated and untreated tyres are very slightly softer and less elastic and more easily penetrated. The worn Ultraseal® treated tyres are slightly less elastic and slightly more penetrable but this has to be balanced against the fact that these tyres have traveled more kilometers and hence were more exposed to heat for longer duration. This longer exposure time to heat and wear is the most likely explanation of the differences, especially when it is noted that the tests of elongation and tensile strength show that the cord is stronger in the Ultraseal® treated tyres, than the controls. As with the tyre, both worn tyres show cord strength less than a new tyre which is not unexpected.

The average (or mean) air permeability shows that Ultraseal® makes the tyre more airtight. In fact it improves the airtight performance by 15% according to the figures presented in reference 97-07-002-11. The authors of that report however have quoted only a 10% improvement. The end result is an improvement in casing life. These are supported by the evidence of the field trials.

The extended mileage can in part be explained by Ultraseal® improving the dynamic balance of the tyre. It must be remembered and emphasized that Ultraseal® effects the static balance and must be applied to tyre rim assemblies that have been balanced prior to Ultraseal® installation.

All the trials that looked at the efficacy of the product as a sealant report the product works as specified (references 97-07-002-5, 6, 8, 12, 13). Moreover, it provides a seal that lasts the life of the tyre (as tested both in the field and in laboratories)

Tests on motor-bikes (reference 97-07-002-14) show even better improvement in terms of balance, wear and puncture resistance, although the raw data is not provided as testimony and is thus not open to independent inspection/confirmation.

The field test on actual working freight lines highlights the results obtained in the other tests. There were no downtime attributable to tyre problems during the 2.5 year trial, the longevity of the tyres in actual practice were 24% greater than the controls, and internal wheel inspections after more than 161,000 km showed no evidence of rust, corrosion or apparent instability of Ultraseal®.

What legitimate claims can be made of the product?

The following claims are supported by evidence in the reports issued to this firm:

- Ultraseal® improves the dynamic balance of tyres
- Ultraseal® does not adversely effect tyre performance (as defined in the test procedures)
- Ultraseal® seals punctures (as described in the test procedures)
- Ultraseal® seals for the lifetime of the tyre (as defined in the test procedures)
- Ultraseal® improves the effective tread life of tyres
- Ultraseal® has been tested and found to be stable under most conditions likely to be encountered
- Field tests indicate that Ultraseal® extends the expected lifetime of a given tyre under average conditions encountered.

Regarding the ATMA statement of October 1989

Disclaimer: The firm was supplied by the client technical reports as outlined in the sample description table (pages 2-3). These reports detail laboratory and field research evidence as to various studied aspects of Ultraseal® The following is based on this documentation and provides data from these sources or calculated results based wholly on the figures as supplied. Statements made regarding the ATMA are done without prejudice or bias. It should be clearly noted by all, that SIRIS Corporation (Aust) Pty Ltd is an independent organization and whilst being contracted by the client, remains neutral and objective in its investigation and findings.

With no disrespect to the ATMA, it is the opinion of the firm, that the ATMA findings are not based on scientific evidence. It would appear that the comments issued were made as a result of a "round-table discussion" of industry experts. The opinions stated are plausible and reasonable on first inspection, however, data presented in the reports you have supplied (and not available to the ATMA at the time they issued their statement) would suggest that the some of the statements are not sound. The documents makes no reference to technical data, nor does it present any information. It should be noted that the issue date of the Bridgestone Technical Service Bulletin is 16-Feb-1990 and the accompanying Public Statement by the ATMA which is the basis of this, was released Oct. 1989. It should also be similarly noted, that the test reports you have forwarded to the attention of the firm, were completed between Nov. 1989 and July 1996.

The document refers to two types of sealants. The only relevant section is that which relates to "Sealants injected as a precaution against punctures".

Point 1: The field tests suggest this point is without practical basis. Compared to the control group that showed tyre damage as expected, the treated group did not over a test period of 2.5 years. The test trials showed that seals had an effective life equivalent to the tyre life. No incident of "dangerous sudden deflation" occurred either within the test or field trials. The causes of these splits in untreated tyres, are varied and not directly within the scope of this discussion.

Point 2: Again field trials and "post-mortum" examinations of the tyres from these tests did not show any evidence of extensive rusting nor structural failure of cords. Cords from treated tyres had worn less than those of untreated tyres.

Point 3: Tests conducted actually showed that dynamic balance is improved by adding Ultraseal®. The second part in this statement "it will be impossible to rebalance the assembly with any lasting success" is not supported by the observations in the trials and laboratories tests. Static balance is affected and thus it is important to add Ultraseal® to tyre rim assemblies that have already been balanced.

Point 4: The field trials and laboratory tests conducted over 1000s of kilometers suggest this comment is without practical basis. It is a reasonable thing to suggest that "any material injected .... may contaminate a valve. This may allow the valve to leak, causing incorrect inflation pressure or a flat tyre". The test results showed that air did not deflate and the nominal 65 psi pressure within the tyres was maintained for the life of the test (an additional 66,000 km post-puncture).

Note 2: Effect on Warranty

....The injection of a sealant (whether before or after damage to the tyre or tube) may under the terms of the relevant manufacturers warranty permit the manufacturer to avoid liability if a fault develops in a tyre or tube due to the injection of the sealant and not through any inherent fault in the tyre or tube"

The test results and post-mortum examination of tyres used in these tests show that the product Ultraseal® does not adversely affect the rubber matrix, nor the embedded cords. Tyres fail due to a number of reasons. One such mechanism that is little spoken about outside of the industry, is the issue of "undercure". As mentioned in the prelude background information, the curing of a tyre is critical to its performance being optimal. Where the tyre did not receive a proper cure during manufacture, the rubber tends to be softer and wears out faster than expected. It is also more easily prone to cuts and punctures and the delamination (peeling off) of the rubber from the reinforcement cords. Additionally a condition known in the industry as rubber creep can occur. Without going into intricate detail, a failure during manufacture to produce a tyre with a properly crosslinked and chemically balanced structure will lead to early demise of the tyre through several mechanisms. These faults can sometimes be quite subtle and easily missed by normal visual and tactile inspection. The cords are treated (plastic type cords are chemically coated whilst steel cords are plated) to allow for strong and uniform rubber to cord attachment. Again the cure system is vital to this occurring properly. A failure to achieve proper bonding can lead to delamination and early demise of a tyre.

It should be clearly noted, that the technology currently exists to conduct post-mortum examinations of tyres that have failed in the field and to determine whether the tyre was undercured during manufacture (irrespective of the age or level of wear of the tyre). Similarly it is easy to conduct specific electron microscopy examinations to determine if corrosion of the reinforcement steel cords had occurred and whether delamination occurred. Similarly, the cords can be examined to establish whether an adequate bond had previously existed. There are a range of standard and in addition to these, a range of specialised tests that can be performed to give evidence as to whether the cause of failure was due to faulty manufacture or induced failure.

Concluding remarks

The product Ultraseal® has been tested and field trialed and has demonstrated a clear advantage to its users (as demonstrated by the technical reports). The product Ultraseal® has been tested and shown to be unlikely to adversely affect tyres or rims. The ATMA statement of October 1989 does not appear to provide a scientific basis for its remarks nor its subsequent attempt to dismiss product liability. In the event of a failure, the technology exists to demonstrate whether it was due to a manufacturing fault or induced by other means or agents (including sealants).