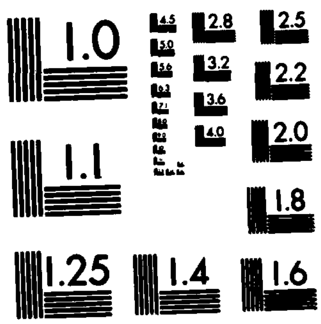
AD-A122 903 BRITTLE FRACTURE OF CRASH HELMETS(U) AERONAUTICAL RESEARCH LABS MELBOURNE (AUSTRALIA) S R SARRAILHE ET AL. FEB 82 ARL-STRUC-389 1/1

UNCLASSIFIED F/G 6/17 NL

END
DATE
FILMED
2 83
DTIC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

ARL-STRUC-REPORT-389 AR-002-332

ADA122903

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

STRUCTURES REPORT 389

BRITTLE FRACTURE OF CRASH HELMETS

by

S. R. SARRAILHE AND G. PAUL

Approved for Public Release

COPY No FEBRUARY, 1982

82 01 03 021

AR-002-332

DEPARTMENT OF DEFENCE
DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
AERONAUTICAL RESEARCH LABORATORIES

STRUCTURES REPORT 389

BRITTLE FRACTURE OF CRASH HELMETS

by

S. R. SARRAILHE AND G. PAUL
AERONAUTICAL RESEARCH LABORATORIES

SUMMARY

The polycarbonate shell of the protective helmet worn by a police motor cyclist shattered in a fatal accident. The conditions which could cause brittle failure in this normally tough material were investigated with particular reference to the effects of hydrocarbon solvents (including petrol), impact at high speed (about 60 km/h) and the support to the helmet provided by the solid test headform. Comparative impacts were made onto a helmet with a fibreglass (GRP) shell.

POSTAL ADDRESS: Chief Superintendent, Aeronautical Research Laboratories,
Box 4331, P.O., Melbourne, Victoria, 3001, Australia.

CONTENTS

1. INTRODUCTION

Polycarbonate* in its intended condition is extremely tough and many of its properties commend it for the shells of protective headgear, including helmets for motor cyclists. However, there have been accidents in which the polycarbonate shell has shattered. Only one case (described below) has been documented in Australia, in other cases, reported overseas the failure has usually been associated with deterioration caused by sunlight, solvent attack, stress concentrations (such as rivet holes) or extreme impact conditions.

Attack by sunlight should be less with opaque helmets than with the earlier transparent shells and solvent contact should be rendered less likely by the warning labels attached to all helmets, but the lack of positive evidence about the reliability of polycarbonate helmets caused the Office of Road Safety (Department of Transport Australia) to support a "weathering trial" on motor cyclists helmets. The trial commenced in 1979 at ARL.

In September, 1980, a police motorcyclist had a fatal accident and his polycarbonate helmet shattered into about 10 pieces. It is shown reassembled in Figure 1. This was the type of occurrence that had prompted the weathering trial, so the experiments were extended to investigate the circumstances which could cause a helmet to shatter.

Fracture of polycarbonate helmets has been reported from the UK and USA and several authorities on helmets and motor cycle accidents were contacted. They were Dr Marshall of Manchester Polytechnic, Dr Hurt of the University of Southern California and Dr Snively of the Snell Memorial Foundation and their helpful comments were appreciated.

The findings, detailed below, were given at the inquest into the death of Leslie Townsend in Melbourne on the 17th of June, 1982.

2. THE TESTS

The tests included the usual procedures for protective helmets described in Australian Standard AS1698 and the American Snell 1975 Standard. In these the helmet was fitted onto a solid metal headform (5 kg mass) and dropped on to a hemispherical anvil with an impact speed of 27 km/h (corresponding to the Snell speed). It was considered that impact at a higher speed (as in a "head on" accident) could be more damaging because of the higher rate of loading and/or the higher energy to be dissipated. It was also considered that the solid headform might limit the deflection of the shell by providing more reinforcement than a real head. As a truly representative head is not obtainable it was decided to make tests using the conventional headform and also to test an empty helmet to represent zero reinforcement from the head. Accordingly a new test was devised in which an empty helmet was held on a solid base and was hit on the side by a 3 kg striker. Striker impact speeds of 10 m/s (36 km/h) and 16 m/s (58 km/h) were used—the lower speed gave approximately the same impact energy as the Snell 1975 test whilst the higher speed corresponds to a reasonable speed on the road. It must be emphasised that this impact is extremely severe:

(a) The energy is nearly 6 times the AS1698 value.

(b) The impact force could not be reduced to a safe level by any practicable helmet.

(c) It is at the limits of survival for occupants in a car crash into a rigid barrier (the maximum design value for seat belts is typically 49 km/h).

* Polycarbonate is a tough mouldable plastic. In the application referred to, pigment had been added to give an opaque white shell. It was not reinforced. Helmet shells are also made from glass fibre reinforced plastic (GRP) commonly refered to as 'fibreglass'.

FIG. 1 POLYCARBONATE HELMET WHICH SHATTERED IN A FATAL ACCIDENT SHOWN REASSEMBLED

(d) It is at the limit of the structural capabilities of most cars (Mille, 1980) and the total distortion would be several times greater than the total width of a helmet.

The test was designed to represent what could happen in an accident, not what could be survived. The rig is described in detail in the Appendix, and the striker, helmet, helmet support and lower part of the rig are shown in Figure 2.

In one test at 16 m/s a wooden headform was fitted inside the helmet to provide the reinforcement present in conventional tests.

In addition some helmets were compressed slowly across their width and small samples, cut from the shell, were subjected to 'Izod' type impacts.

To determine the effect of solvent on performance, helmets and Izod samples were tested after being moistened with the ASTM Standard Fuel Specification 'C', as recommended in the proposed amendment to the British Standard specifications, BS2495–1977, and BS5361–1976. This is a mixture of 50% toluene and 50% iso-octane. Izod samples were also treated with 'super' grade petrol.

3. THE HELMETS

The majority of the helmets were Police issue Eldorado MHI polycarbonate helmets, but to provide balance and allow comparison with the other common shell material, Bell Super Magnum helmets with fibreglass shells were also tested. All of these helmets were from Victoria Police stores, most had been used and some had been withdrawn from service because of age or damage. Most of the samples used in the 'Izod' tests were cut from an unused helmet.

4. RESULTS OF TESTS ON HELMETS

4.1 Helmets Tested as Received

All the helmets withstood the conventional tests (i.e. AS1698 and Snell 1975 spherical anvil impacts) without failure. The surfaces of the fibreglass shells were cracked at the impact site but the polycarbonate shells did not show any damage. The deceleration of the head form was measured in some tests and was about 130 g in all of these. High speed films of selected impacts showed that the polycarbonate and fibreglass shells deflected by about the same amount as shown in Figure 3.

With the new impact test on empty helmets the deflection was extreme, as shown in Figure 4. Several new polycarbonate helmets withstood repeated impacts without fracture, one polycarbonate helmet cracked at a maximum sideways compression of 86 mm at the striker. The crack ran along pre-existing scratches as shown in Figure 5. In another test, an old, used helmet broke on the side away from the striker. The only fibreglass helmet in this group tested was penetrated by the striker to a depth of 83 mm below the original surface. This is shown in Figure 4, the position of the striker within the helmet was deduced from the part of the striker which was visible.

4.2 Helmets Tested after Treating with Solvent

All helmets withstood the usual impact on to the spherical anvil. Impact decelerations and deflections were similar to those with the untreated helmets.

The helmets also withstood the new impact tests at 10 m/s without fracture. The sideways compression of the polycarbonate helmet was 54 mm (at the striker). The striker made a small hole through the fibreglass shell and the maximum penetration plus sideways compression was 53 mm.

A polycarbonate helmet fitted on to a solid headform and struck at 16 m/s withstood the impact without fracturing.

An empty fibreglass helmet when struck at 16 m/s was penetrated by the striker in the same way as the untreated helmet.

FIG. 2 POLYCARBONATE HELMET ON HIGH IMPACT TEST RIG
Helmet treated with A.S.T.M. Std. Fuel 'C'

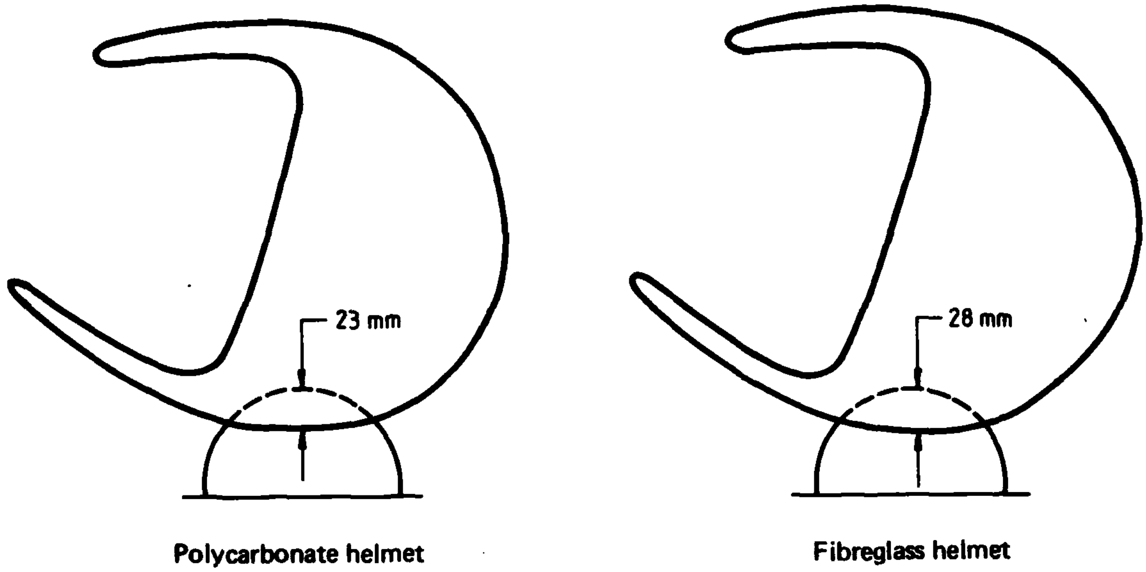


FIG. 3 PROFILE OF HELMET AT LOWEST POSITION DURING IMPACT ONTO HEMISPHERICAL ANVIL (from high speed film)

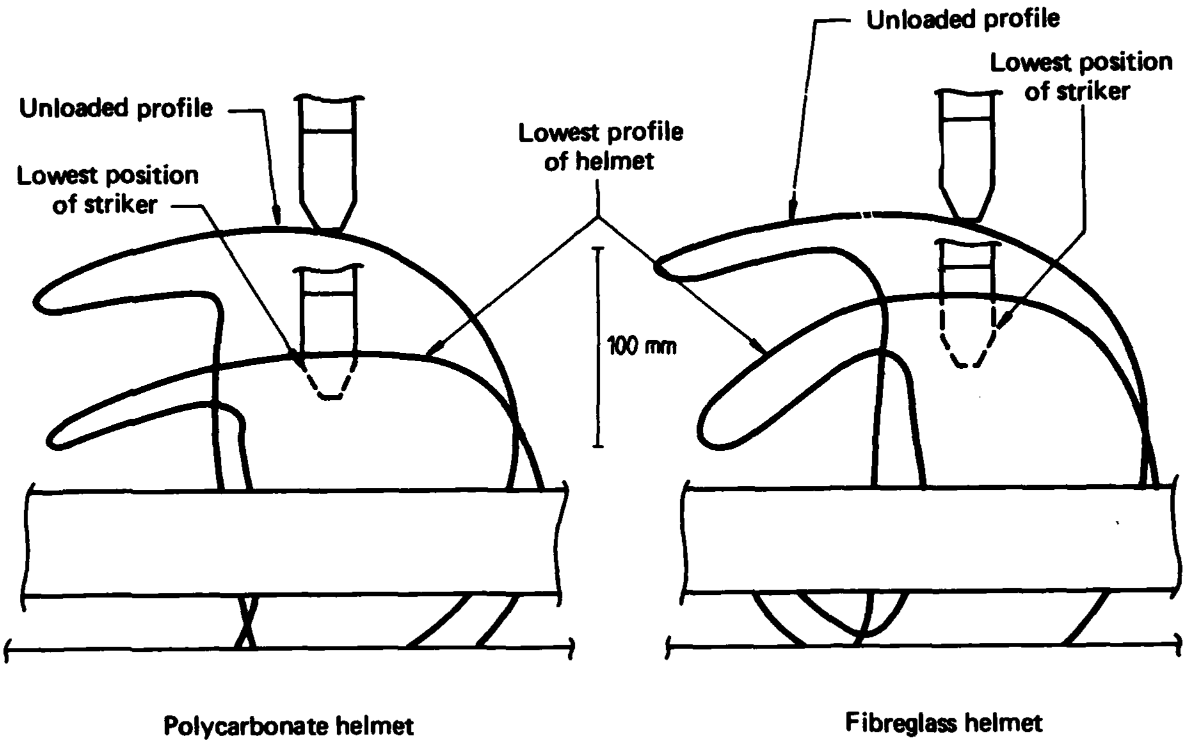


FIG. 4 PROFILE OF SHELL DURING HIGH SPEED IMPACT TEST ON AN EMPTY HELMET (from high speed film) Velocity: 16 m/s Helmet tested as received.

FIG. 5 UNTREATED POLYCARBONATE HELMET AFTER HIGH IMPACT TEST

The most dramatic change from previous results was when the treated, empty, polycarbonate helmets were struck at 16 m/s. All helmets shattered, and a typical result is shown on Figure 6. The shell initially deflected but after compressing by about 60–80 mm it cracked at and around the impact point as shown on Figure 7.

4.3 Static Tests

An unused Eldorado helmet and a Shoei fibreglass helmet which had been in an accident but which only had surface scratches, were compressed across their width in a testing machine. Compression and force were noted and it was found that until the opposite sides touched, the stiffness of the two helmets was approximately the same. Views of the helmets under load are shown in Figure 8. Two Eldorado helmets were also compressed in a different machine between a flat platen and a ram shaped like the striker. Both helmets had received high speed blows previously. One helmet, which had not been treated with solvent, deflected 100 mm without fracture before the test was terminated, the other, treated with the test solvent fractured when the deflection reached 65 mm. Force/deflection curves were plotted automatically and are shown on Figure 9. The previous tests would have left stresses in the helmet so it would have been attacked abnormally by the solvent. However, the test shows that even in this condition the helmet could deflect considerably before failure. The failure was similar to that which occurred in the dynamic tests so it would seem that one of the principal causes of the brittle fracture was the large deflection.

The force/deflection curve for the solvent treated and untreated helmets were similar up to the point of failure, indicating that the solvent did not effect the stiffness.

5. TESTS ON SAMPLES OF MATERIAL

Whilst there is very little published information on embrittlement of helmets, the causes of embrittlement in polycarbonate, based on tests on samples cut from sheet material, have been described in a number of reports.

The solvents which attack polycarbonate cause cracks or crazing of the surface, these act as stress concentrators and embrittle or reduce the toughness of the material. The attack is greatly accelerated if the polycarbonate is under stress while the solvent is applied.

Walters (1978) stated that aviation fuel caused crazing at 5·8 MPa, (about 10% of the ultimate strength), Miller (1971) showed a reduction in strength by more than 80% as a result of carbon tetrachloride attack and Hassard (1972) reported that mechanically cut notches (which also act as stress concentrators) reduce "toughness' as measured by an Izod type test by more than 90%.

To check the effect of relevant solvents on helmet shell material, specimens approximately 5 mm square and 40 mm long were cut from several shells, (the majority were from a helmet which was purchased in 1979 and stored since). The specimens were stressed, wiped with a solvent and tested in a small Izod machine (2·7 J maximum energy). They were not standard Izod test specimens nor were they notched.

To stress them they were placed in a bending rig as shown in Figure 10. They were then moistened with a solvent, either ASTM standard fuel "C" or "super" grade petrol.

Tests were also made on specimens which were neither stressed nor treated with solvent, treated with solvent but not stressed, or stressed but not treated with solvent. In the subsequent Izod test these specimens bent, but did not break and they absorbed 1·1 to 1·4 J of energy.

Most of the specimens which had been exposed to solvent while under stress snapped cleanly in the Izod test and the energy absorbed varied inversly with the stress acting during the solvent attack as shown in Figure 11. When the stress was less than 1 MPa during solvent attack the energy absorbed was usually 0·9 to 1·3 J and the specimens bent but when the stress was greater than 1·5 MPa the energy absorbed was usually less than 0·3 J and the specimens broke. Stresses above 2·4 MPa produced visible cracks and when the stress was greater than 10 MPa the specimen fractured under the static load, (during the 10–30 minute period allowed between moistening the specimen and transfering it to the Izod machine). An untreated specimen could support a 1 kg mass (with considerable deflection) corresponding to a stress of approxi-

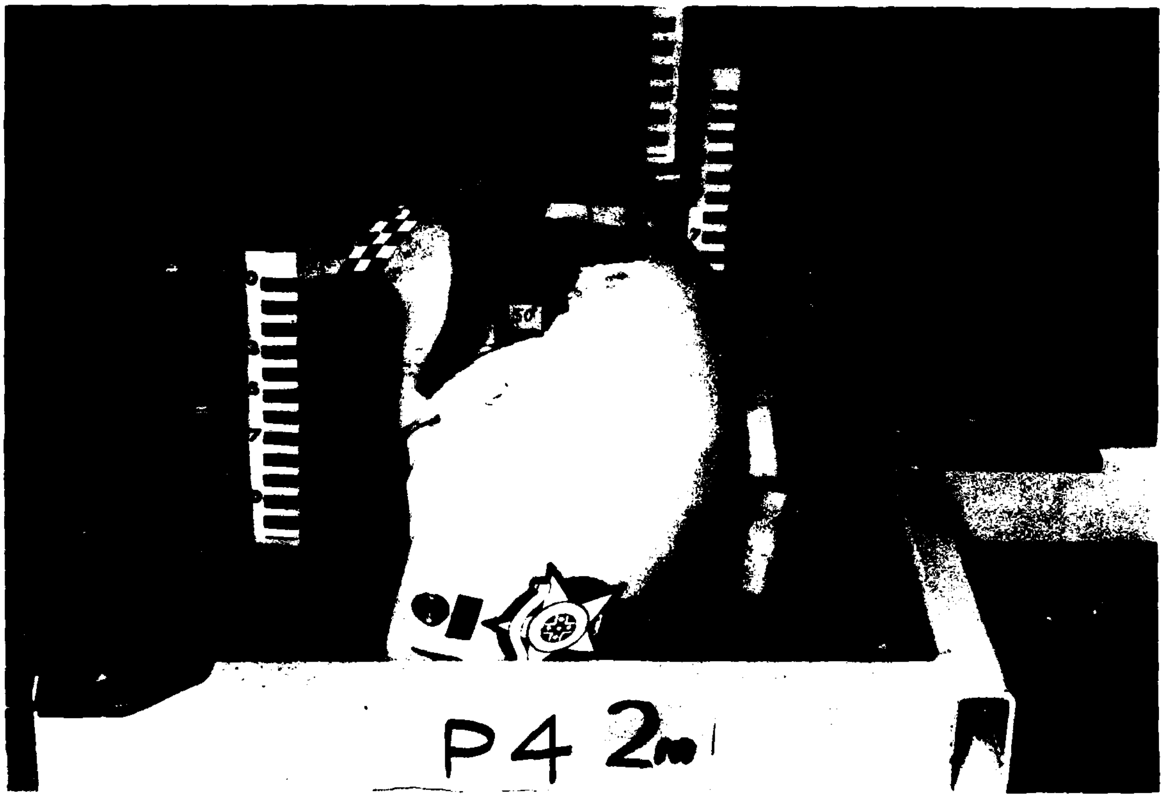


FIG. 6 POLYCARBONATE HELMET AFTER HIGH IMPACT TEST.
HELMET TREATED WITH A.S.T.M. STD. FUEL 'C'.
Mass of striker – 3 kg
Velocity of striker – 16 m/s

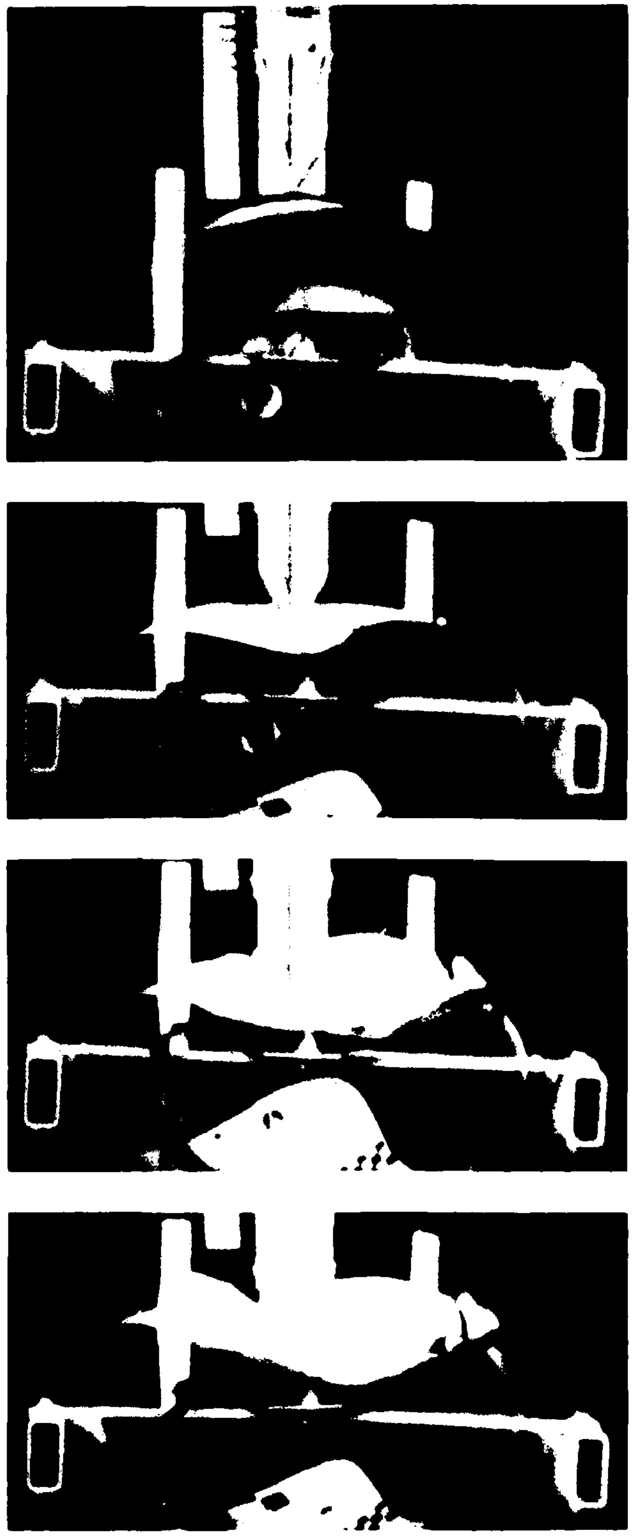


FIG. 7 POLYCARBONATE HELMET TREATED WITH A.S.T.M. STD. FUEL 'C'
IMPACT AT 16 m/s. Photos approximately at contact and 0.005, 0.0075 and 0.01 seconds later.
(from film at about 4000 frames per second)

FIG. 8(a) FIBREGLASS HELMET WITH MOULDED PLASTIC CHIN GUARD
LOAD = 5 kN

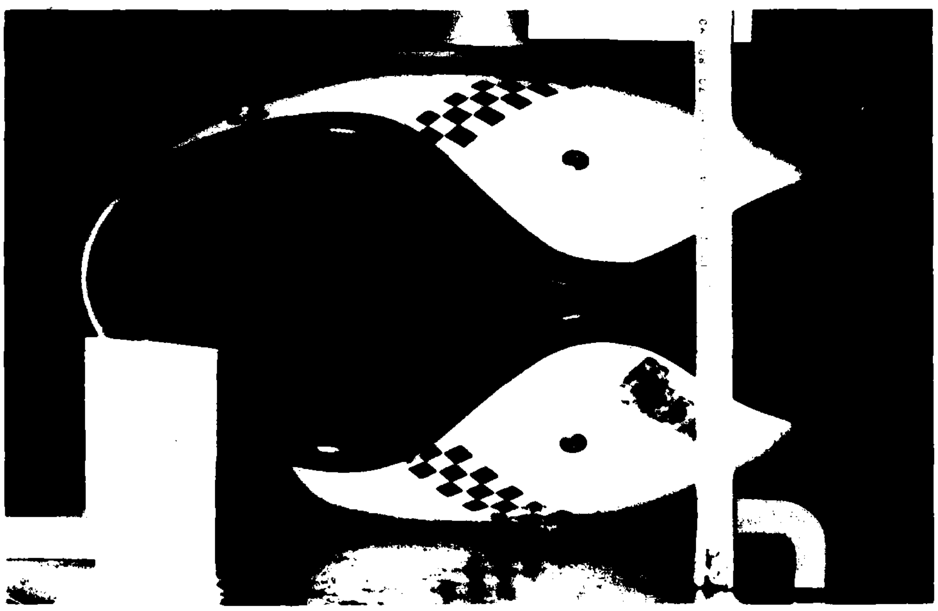
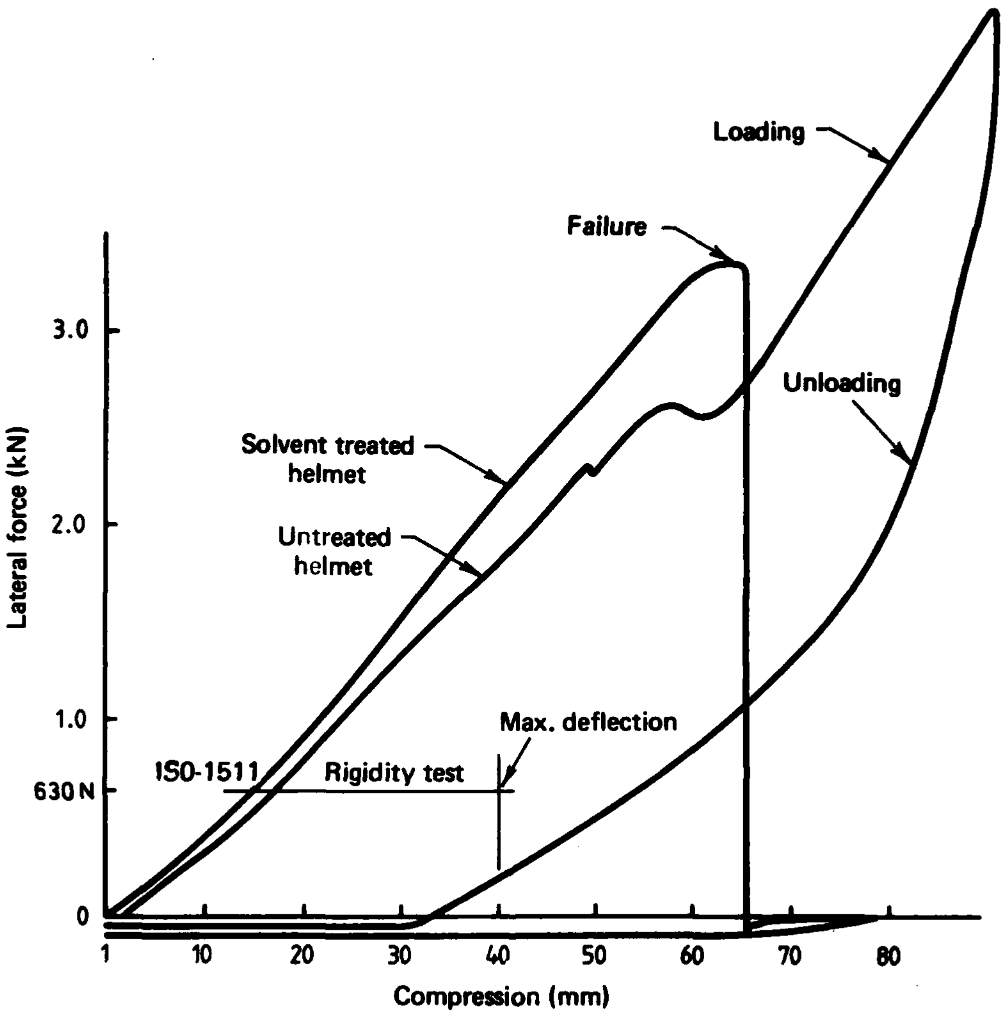


FIG. 8(b) POLYCARBONATE HELMET
LOAD = 4 kN



Note: Rigidity test of ISO standard 1511 states the deflection must not exceed 40 mm at a load of 630 N.

FIG. 9 COMPRESSION TEST (side to side)
Compression rate 5 mm/sec

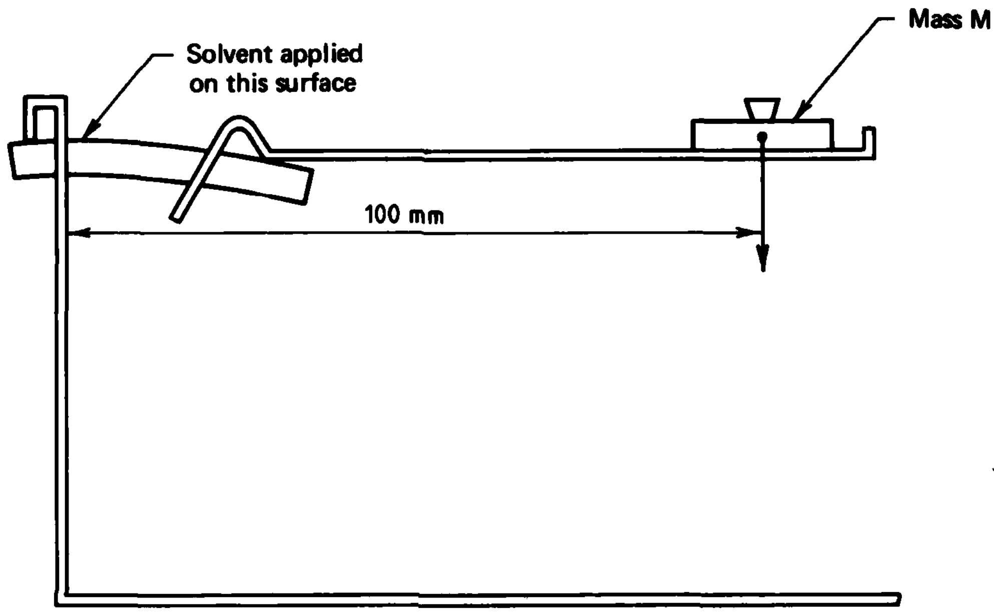


FIG. 10 BENDING RIG
(Stress ≃ 4.7 MPa per 100 gm for typical specimen)

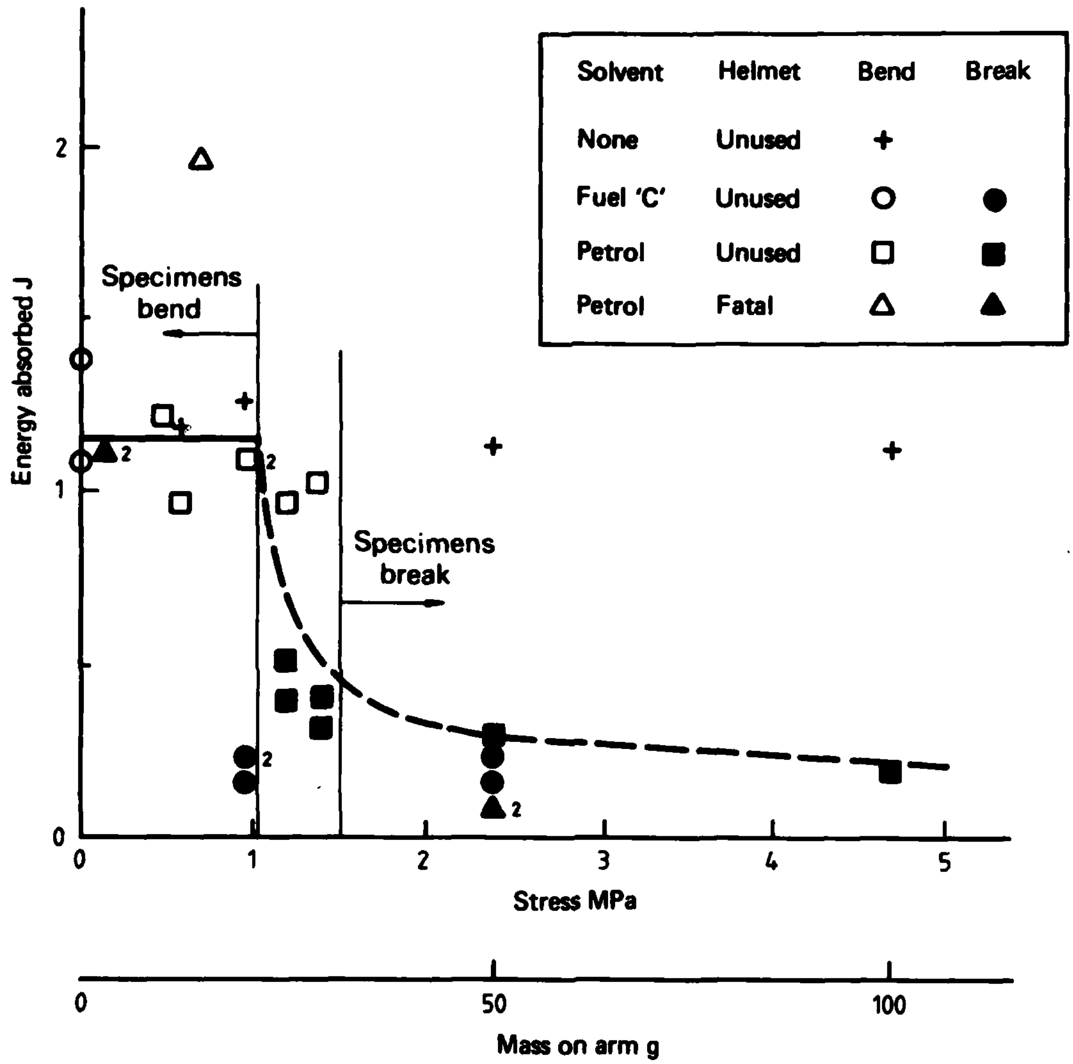


FIG. 11 EFFECT OF STRESS DURING SOLVENT ATTACK ON IZOD ENERGY

mately 50 MPa. Consistent brittle failure with low energy absorption occurred with a stressing mass of 30 gm, giving 1·4 MPa, i.e., only 3% of the stress that the material could support.

6. THE WEATHERING PROGRAM

Three specimens of seven models of helmets, including three with polycarbonate shells, were exposed on a north facing roof at ARL. Two of each model were tested at intervals and after 12 months no deterioration was detected (as indicated by the standard penetration test of AS1698). After eighteen months one helmet cracked around an impact point with the crack running through a previous impact site, as shown in Figure 12. It is considered that this shows deterioration as a result of weathering, but the other exposed helmets must be tested before conclusions can be drawn.

7. DISCUSSION

1. The fracture of the police motorcyclist's helmet is the first fully documented accident to be reported to the SAA technical committee for protective helmets.

2. Neither the Traffic Accident Research Unit in Sydney nor the Adelaide University Accident Research team have found a case of a helmet shattering.

3. Brittle fractures have occurred overseas but they are not common. Dr Snively (1981) of the Snell Memorial Foundation noted, in correspondence, that fractures had occurred in accidents and tests. Both he and Dr Hurt (1981) of the Traffic Safety Centre, University of Southern California, in correspondence refer to the 'occasional failures'. Dr Marshall (1981) of Manchester Polytechnic noted that in a large survey they had 'many helmets' which had shattered. Each of these authorities was concerned about the sensitivity of the material to deterioration.

4. Usually fractures are related to stress concentrations such as cracks, scratches or solvent attack, but some cases apparently occur without these factors.

5. The helmets tested at ARL only shattered when they were struck with such violence that survival would be impossible with any helmet.

6. With one exception, recent polycarbonate helmets only shattered if they had been moistened with solvent. The exception was a used helmet with unknown history.

7. In the high speed impacts onto fibreglass helmets, the striker penetrated deeply into the head space.

8. One of several different types of helmet exposed to the weather showed some signs of embrittlement, but tests are not yet complete.

9. Dr Hurt in reference to the protective performance of "high price, high performance helmets" and "low price Polycarbonate helmets", noted that "many motorcyclists are saved by both".

10. On the other hand the impact strength of Polycarbonate can be greatly reduced by notches, scratches or imperfections or by the action of common solvents including 'super' grade petrol. The action of solvents is complex depending on the state of stress of the plastic, as well as the composition and concentration of the solvent. All polycarbonate helmets treated with the solvent shattered in the ARL high energy impact test. Thin strips of shell material stressed to 10 MPa in a bending rig and moistened with petrol cracked right through. Specimens stressed to 1·5 MPa were shown by Izod type tests to be embrittled but did not have any visible damage. Other sources indicate that sharp notches or solvent can destroy more than 90% of the strength or toughness.

8. SUMMARY OF RESULTS

Polycarbonate and fibreglass helmets were tested as received and after treating with solvent:

1. None of the polycarbonate or fibreglass helmets shattered when tested with the conventional test procedures with a solid headform and hemispherical anvil.

2. When the helmets were tested empty with an extremely severe impact (58 km/h) the striker penetrated about 80 mm into the fibreglass helmets. Most of the polycarbonate helmets

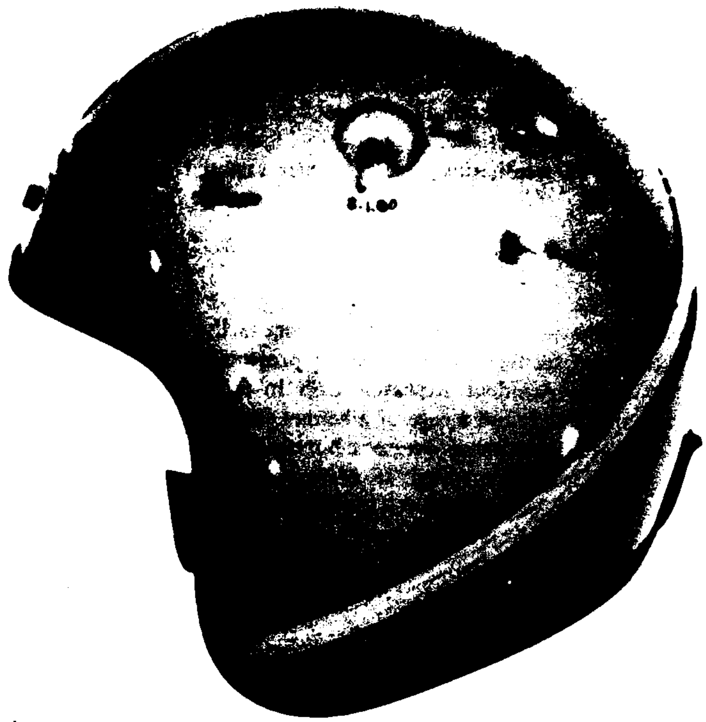


FIG. 12 POLYCARBONATE HELMET AFTER 18 MONTHS EXPOSURE TO WEATHER. DAMAGE CAUSED BY PENETRATION. EXPOSURE COMMENCED ON 13.6.79. DATE OF TEST SHOWN ADJACENT TO IMPACT.

tested as received compressed across the width by about 80 mm without fracture. All solvent treated polycarbonate helmets shattered after deflecting by 70–80 mm.

3. Slow side-to-side tests showed that the solvent did not effect the stiffness of the helmet but the treated helmet shattered when the deflection reached about 65 mm, in the same way as the treated helmets in the impact tests.

4. A treated polycarbonate helmet struck at 58 km/h but prevented from deforming by a solid headform did not fracture.

5. Tests on small samples of material cut from helmet shells indicated that both the standard solvent (ASTM Fuel C) and several brands of 'super' grade petrol would cause embrittlement. Damage depended on the stress in the polycarbonate while the solvent acted and was detected with stresses as low as 1 MPa.

6. The fibreglass and polycarbonate helmets had about the same stiffness when compressed from side to side and deflected about the same amount in impact tests.

7. Polycarbonate shells recovered from moderate impacts (e.g. the conventional flat or hemispherical anvil tests) without visible damage whereas the fibreglass shells cracked. In post accident analysis this may result in underestimation of the severity of impacts onto polycarbonate helmets, in comparison with impacts of similar severity on fibreglass helmets. It follows that for accident investigation the liner must also be examined and the best way to get access to this is to cut the helmet in half.

8. The resilience of polycarbonate caused the helmet and head form to rebound a little more than the glassfibre helmets after impact, the respective ratios of rebound to impact velocity were 0·46 and 0·27.

9. CONCLUSIONS

1. The tests showed that small quantities of hydrocarbon solvent, such as petrol can cause embrittlement in polycarbonate.

2. The extent of embrittlement depends on the stress in the polycarbonate at the time when it is exposed to the solvent. If the stress is very low, attack may be minimal but higher stress can reduce impact resistance by 90% or even cause cracking through the full thickness of the plastic.

3. It follows that the susceptibility of a moulded product, such as a crash helmet, to solvent will depend to a large extent on the presence of any residual stresses remaining from the manufacturing processes.

4. The particular brand of helmet, tested after exposure to solvent:
   (a) did not fracture in the conventional tests or when supported on a solid headform and struck at high speed,
   (b) shattered when struck at high speed, without the support of a headform.

5. In relation to the fatal accident it is considered that:
   (a) the impact was very severe and also,
   (b) the helmet had been contaminated, perhaps inadvertently.

REFERENCES

Australian Standard 1698–1980—"Protective helmets for vehicle users". Standards Association of Australia, North Sydney, N.S.W.

British Standard 2495–1977—"Protective helmets for vehicle users (high protection)". British Standards Institution, London.

British Standard 5361–1976—"Protective helmets for vehicle users". British Standards Institution, London.

Hassard, R. S. (1972)—"Design criteria—Transparent polycarbonate plastic sheet". Goodyear Aerospace Corporation for Air Force Materials Laboratory, Air Force Command, Wright Patterson Air Force Base, Ohio. AFML–TR–72–117. August, 1972.

Hurt, Hugh, H. Jr. (1981)—The Traffic Safety Center, Institute of Safety and Systems Management, University of Southern California. Correspondence 2 March, 1981.

Marshall, G. P. (1981)—Department of Polymer Technology, Chester Street, Manchester, M15GD. Correspondence, 17 February, 1981.

Miller, G. W., Visser, S. A. D., and Morecroft, A. S. (1971)—"Solvent stress cracking of polycarbonate". Polymer Engineering and Science, Vol. 11, No. 2, 1971.

Miller, Patrick and Rydzynski, Paul, A. (1980)—"Analysis of frontal impact test data—New car assessment project". MGA Research Corporation for Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C. DOT–HS–805–395. February, 1980.

Snell 1975—"Standard for protective headgear 1975". Snell Memorial Foundation, Sacromento, California.

Snively, M. D., George, G. (1981)—Snell Memorial Foundation, Sacramento, California. Correspondence, 17 February, 1981.

Walters, B. J., and Thacker, R. I. (1978)—Polycarbonate transparent materials. British Aerospace (Warton) for Ministry of Defence (UK), MDR0132, March, 1978.

APPENDIX

The High Energy Impact Test—HIT

The lower part of the rig is shown on Figure 2. The helmet was supported by an internal profile plate and external pads with the lower side resting on a wooden block set in sand. The 3 kg striker could slide freely on the vertical guide rail and was accelerated downwards by 13 mm diameter shock cord. A pair of pulleys, similar to those in Figure 2, fitted at the top of the rig (2·3 m above the lower pair) allowed the use of 4·3 m of shock cord on each side so that when the striker was raised to its highest position the stretch of the shock cord was not excessive.

The guide rail was 3 m long and ended just above the helmet.

The striker was raised to 2 m above the helmet for impact at 16 m/s or 1 m for impact at 10 m/s.

The conical striker was truncated to a diameter of 10 mm to match the contact mark on the helmet which shattered in the accident, but it is considered a suitable shape for general use.

The striker was released by a bomb release on the lifting tackle. Velocity was measured by a photo electronic system and significant impacts were filmed at about 4000 pps this gave excellent resolution of the impact and the shattering process.

DISTRIBUTION

AUSTRALIA

Department of Defence

Central Office

Chief Defence Scientist
Deputy Defence Scientist
Superintendent, Science and Technology Programmes
Controller, Projects and Analytical Studies
} (1 copy)

Aust. Defence Scientific and Technical Rep. (U.K.) –
Counsellor, Defence Science (U.S.A.) –
Defence Central Library
Document Exchange Centre, D.I.S.B. (17 copies)
Joint Intelligence Organisation
Librarian H. Block, Victoria Barracks, Melbourne
Director General—Army Development (NSO) (4 copies)

Aeronautical Research Laboratories

Chief Superintendent
Library
Superintendent—Structures
Divisional File—Structures
Author: S. R. Sarrailhe
G. Paul

Materials Research Laboratories

Chief Superintendent/Library

Defence Research Centre

Library

Navy Office

Navy Scientific Adviser

Army Office

Army Scientific Adviser
Engineering Development Establishment, Library

Air Force Office

Air Force Scientific Adviser
Technical Division Library

Department of Industry and Commerce

Government Aircraft Factories

Manager
Library

Transport Australia

Library
Flying Operations and Airworthiness Division
Director of Aviation Medicine
Chief, Research Section, Office of Road Safety

Statutory and State Authorities and Industry

N.S.W. Department of Motor Transport, Traffic Accident Research Unit
- Mr D. Herbert
- Dr Arthurson
- Library

Standards Association of Australia
- Secretary Committee AU/12 (27 copies)
- Secretary Committee CS/14 (26 copies)
- Secretary Committee SF/18 (22 copies)
- Quality Assurance Division

Technisearch Ltd., Testing Division, Mr W. Sidebottom

Australian Road Research Board, Dr M. Wigan

Road Safety and Traffic Authority
- Chairman
- Library

Victoria Police
- Chief Commissioner
- Commissioner Martin

SEC of Vic., Herman Research Laboratory, Library

B.H.P., Melbourne Research Laboratories

Australian Institute of Petroleum Ltd

Telecom Australia, Mr R. Boast

Universities and Colleges

Adelaide	Barr Smith Library
	Road Accident Research Unit, Dr A. J. McLean
	Professor of Mechanical Engineering
Melbourne	Engineering Library
Sydney	Engineering Library
N.S.W.	Physical Sciences Library
	Professor R.A.A. Bryant, Mechanical Engineering
	Assoc. Professor R. W. Trail-Nash, Civil Engineering
Queensland	Library
Western Australia	Library
R.M.I.T.	Library
	Dr H. Kowalski, Mech and Production Engineering

CANADA

CAARC Coordinator Structures

International Civil Aviation Organization, Library

NRC
- Aeronautical and Mechanical Engineering Library

Universities and Colleges

Toronto	Institute for Aerospace Studies

INDIA

CAARC Coordinator Structures

NEW ZEALAND

Universities

Canterbury	Library

SWITZERLAND

F+W (Swiss Federal Aircraft Factory)

UNITED KINGDOM

CAARC, Secretary (NPL)
Royal Aircraft Establishment
Bedford, Library
British Library, Lending Division
CAARC Co-ordinator, Structures
British Standards Institution
Director
Protective Helmet Committee
International Standardisation Organisation
Protective Helmet Committee

Universities and Colleges

Cranfield Inst. of Technology	Library
Manchester Polytechnic	Dr G. F. Marshall

UNITED STATES OF AMERICA

NASA Scientific and Technical Information Facility
Allis Chalmers Corporation, Library
Snell Memorial Foundation, Dr G. G. Snively

Universities and Colleges

Massachusetts Inst. of Tech.	M.I.T. Libraries
Michigan	Highway Safety Research Institute, Dr R. G. Snyder
Southern California	Institute of Safety and Systems Management, Dr H. H. Hurt

Spares (10 copies)

TOTAL (186 copies)

DOCUMENT CONTROL DATA

1. a. AR No AR-002-332	1. b. Establishment No ARL-Struc-Report-389	2. Document Date February, 1982	3. Task No. 89/118
4. Title BRITTLE FRACTURE OF CRASH HELMETS		5. Security a. document Unclassified b. title U c. abstract U	6. No. Pages 7. No. Refs 11
8. Author(s) S. R. Sarrailhe G. Paul		9. Downgrading Instructions —	
10. Corporate Author and Address Aeronautical Research Laboratories		11. Authority (*as appropriate*) a. Sponsor b. Security c. Downgrading d. Approval a) Department of Transport Australia; Office of Road Safety	

12. Secondary Distribution (*of this document*)
Approved for public release
Overseas enquirers outside stated limitations should be referred through ASDIS, Defence Information Services Branch, Department of Defence, Campbell Park, CANBERRA ACT 2601

13.a. This document may be **announced** in catalogues and awareness services available to . . .
No limitations

13. b. Citation for other purposes (*i.e. casual announcement*) may be unrestricted

14. Descriptors		15. COSATI Group
Road safety	Motor vehicle accidents	0617
Safety engineering	Polycarbonate resins	1312
Helmets	Protective equipment	
Motorcycles		

16. *ABSTRACT*

The polycarbonate shell of the protective helmet worn by a police motor cyclist shattered in a fatal accident. The conditions which could cause brittle failure in this normally tough material were investigated with particular reference to the effects of hydrocarbon solvents (including petrol), impact at high speed (about 60 km/h) and the support to the helmet provided by the solid test headform. Comparative impacts were made onto a helmet with a fibreglass (GRP) shell.

17. Imprint
Aeronautical Research Laboratories, Melbourne

18. Document Series and Number Structures Report	19. Cost Code 269052	20. Type of Report and Period Covered

21. Computer Programs Used

22. Establishment File (Ref(s)) E2/30/3

LME

8