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DEPARTMENT OF MOTOR TRANSPORT N.S.W.

CRASH PROTECTION FOR THE SUB-TEEN CHILD

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CONTENTS

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SUMMARY

This report describes a program of simulated car crashes and examinations designed to evaluate the child restraints currently available in Australia.

Each restraint was subjected to crash simulations producing deceleration forces equal to 17 times the weight of the occupant. During each crash, data such as harness forces, deceleration and velocity were recorded and high speed movies were provided.

It was concluded that, in general, SAA-approved devices afforded a degree of protection adequate to ensure survival of the occupant in most real life frontal collisions; there were, however, some aspects of approved devices which could have been improved. In general, non-approved devices were considered inadequate, in at least some respects; some devices could easily be modified to satisfy safety requirements.

The report concludes with detailed appraisals of 21 commercial products manufactured in Australia, Canada, Britain or the United States of America.

PART I

INTRODUCTION TO CRASH PROTECTION

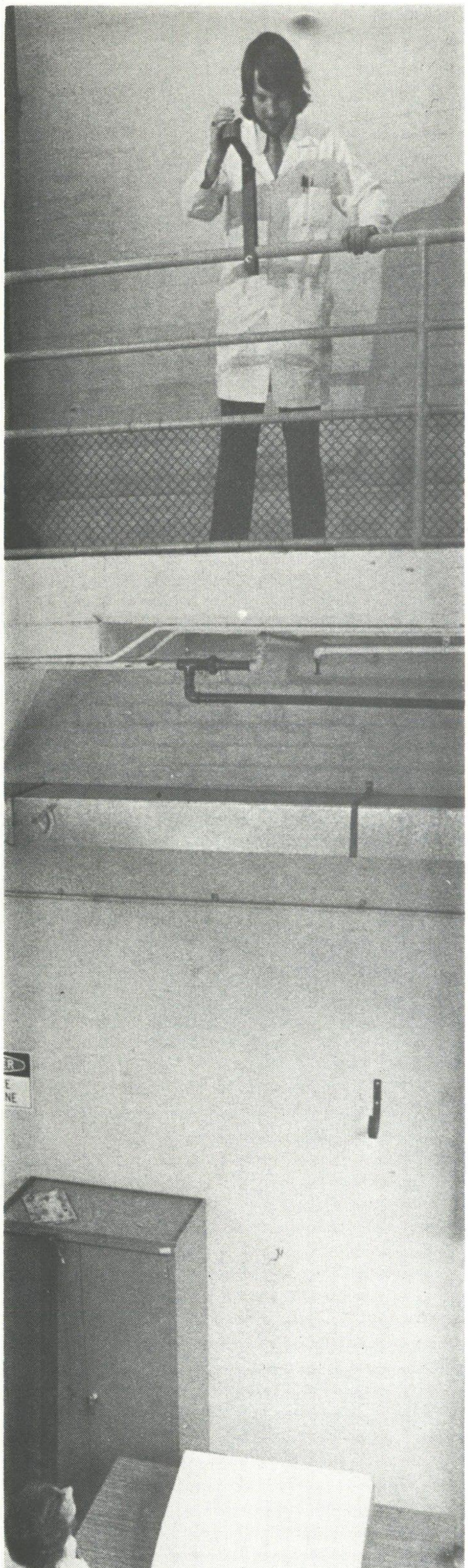
GENERAL

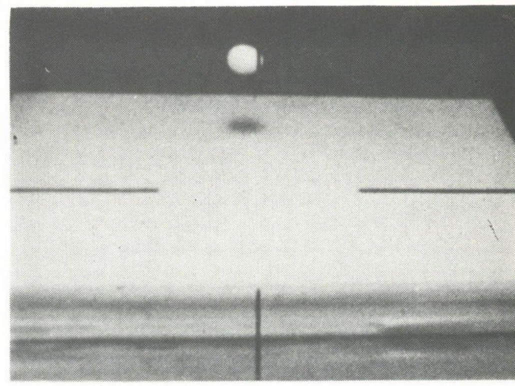
In this paper we investigate the crash protection of sub-teen children, that is those who are old enough to sit up unaided, but who are too small to wear the lap/sash seat belts provided for adults in the four outboard seating positions of all new cars produced in Australia. All experimental results reported in two earlier papers by Herbert et al.[19,21] have been included. Babies are excluded; their crash protection has been discussed recently by Vazey et al.[22]. Teenage children are also excluded; they are usually large enough to find lap/sash belts comfortable, convenient and safe to use.

Crash protection, whether for child or adult, can be seen as a systems problem. It consists in bringing a vehicle to a stop, in a crash, in such a manner as to reduce to a practical minimum the injuries sustained by the vehicle occupants. Crash protection of people has often been likened to packaging of consumer goods: eggs are delivered in packages that prevent breakages even when the sealed container is dropped; but egg cartons have their limitations and eggs break if the package is dropped from too great a height. Better protection may be designed so as to provide protection in falls from great heights. Figure 1 is a photograph of a test set-up in which an egg is dropped on to a pad after falling 5 metres, and is caught after bouncing off the pad, without damage. Similarly successful experiments have been conducted with falls up to 15 metres.

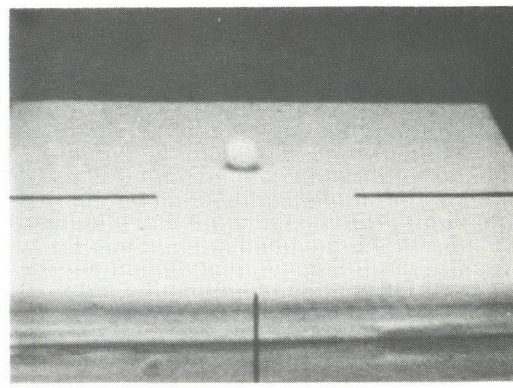
The characteristics of successful packaging are as follows:

- The casing does not break, or spill its contents, in a crash.
- The contents are supported within the casing so as to limit deceleration forces on vulnerable parts of the contents.
- Any actual crash lies within the limits of crash severity for which the package has been designed.

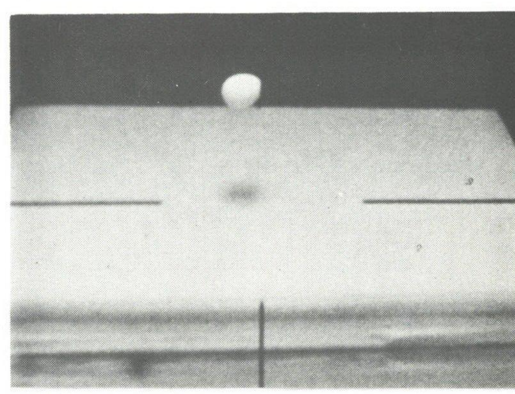




Before Impact



At Impact



After Impact

FIGURE 1

EGG DROPPING EXPERIMENT

The crash protection package is a system comprising a casing or shell, a support or restraint, and contents to be protected. The system design must have regard for the crash characteristics of each of these three components in isolation and for coupling effects arising when they crash together.

We have assumed that the vehicle shell will remain intact in crashes for which child protection systems are designed. This is not always true, but we believe that there are sufficient crashes in which modern passenger cars suffer little loss of survival space, for our assumption to form a valid basis for packaging design. Extension of protection to more severe crashes depends then, in part, upon an improvement in the performance of the vehicle shell, a subject that will not be pursued at length here.

The supports or restraints available to the sub-teen child, apart from seat belts designed for adults, are harnesses of various descriptions, child seats incorporating harnesses, and child seats designed in such a way as to provide restraint without the necessity for a harness. Restraints may be designed to face forwards in the car, rearwards or either. Whichever direction they may be facing after installation, they should clearly provide protection in front, rear and left-and-right-hand side impacts as well as in roll-overs.

Child restraints may be approved or not approved by a competent authority. In Australia the Standards Association of Australia operates a voluntary licencing scheme under which manufacturers may use the Association's Trade Mark (Figure 2) provided that their products comply with relevant Australian Standards. Compliance has to be demonstrated by independent evaluation and testing before a licence is issued and by routine testing by the manufacturer to indicate a measure of quality control. One of the objects of this paper is to compare SAA-approved child restraints with non-approved restraints with a view to appraising the effectiveness of the Australian Standard[1] in specifying viable systems for crash protection.

FIG. 2. SAA APPROVAL SYMBOL

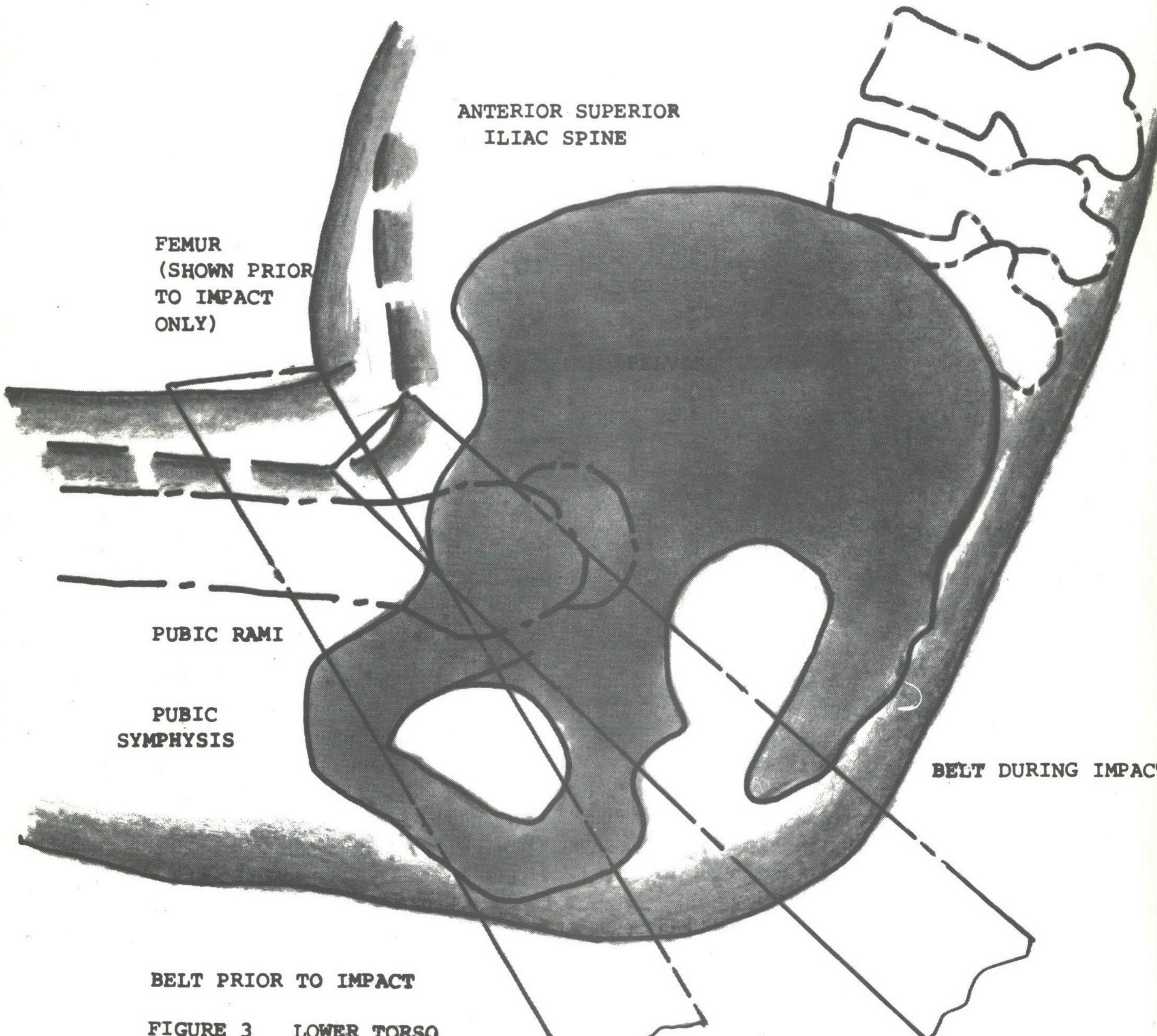


FIGURE 3 LOWER TORSO RESTRAINT

PERFORMANCE REQUIREMENTS

Given that car design is restricted by virtue of the fact that we are considering only current models, and given a range of sizes and ages of human occupants, the task of the designer of a child restraint clearly consists in providing all those parts that may be required in order to produce a viable system of crash protection. No less important is the requirement to allow any car seating position occupied by a restraint, to be readily and speedily converted back to adult use, as necessitated by changes of occupancy.

Correct adjustment of a restraint has been shown to be important for adults, to reduce injuries to a minimum. This is seen to be equally important for children. Moreover, the larger number of straps in the harnesses commonly provided in child restraints present greater problems of adjustment, so that loose adjustment appears to be more difficult to avoid with children. Loose adjustment of child restraints is potentially dangerous because of the possibility that shoulder straps might fall, or be pushed by the occupant, off the shoulders, hence allowing ejection in an accident or even during severe braking. Harness and buckle designs for young children need to be generally "fiddle-proof" if the occupants are to be protected adequately. These problems present a considerable challenge to designers of child restraints. We will try to evaluate the success with which the challenge has been met, for each device evaluated, but we must acknowledge at the outset the subjective nature of many appraisals of this kind: the challenge to us has been to be as objective as possible.

The chief safety requirements of a child restraint are:

- The device shall be strongly attached to the car, to prevent the occupant being ejected in the device.
- Harnesses shall be easily adjustable, to prevent ejection and to limit forward and sideways movement so as to prevent head impact with rigid parts of the car interior.

- The device shall prevent ejection in a crash and shall restrict restraint forces to those parts of the occupant's anatomy that are most able to withstand large forces.

These requirements cannot be met in all situations with current technology, without restricting the child's movements somewhat. Like an adult in a seat belt, he must occupy a seat, have the restraint adjusted properly, and must suffer some degree of inconvenience. Child restraints can however be designed to meet safety requirements whilst being:

- easily installed
- easily removed again
- comfortably worn
- easily adjusted
- easily released by an adult rescuer, and
- relatively "fiddle-proof"

Child harnesses are available that make use of lap belts already installed for adults. Lap belts are not regarded as providing good protection, especially for adults, so the addition of a shoulder strap can only be seen as beneficial. This is usually only practicable in rear seats and in sedans, because of the absence of a suitable anchorage for the shoulder straps in front seats and in rear seats of station waggons, although the wheel arches may sometimes provide anchorages. We have included some of these restraints among our evaluations.

The maximum level at which crash protection should be required of a child restraint is a matter for debate but in view of the limited performance of existing car shells, there is little point in requiring the child restraint to achieve exceptionally high performance.
There are at present no mandatory crash requirements set by Australian Design Rules[23] other than ADR 10B which requires for 1973 and later models a 48 km/h (30 m.p.h.) barrier test designed to limit intrusion of the steering column in frontal crashes. This probably limits the loss of occupant space generally in such crashes and suggests a suitable starting point for setting performance limits. In the United States of America,

Federal Motor Vehicle Safety Standards[24] similarly limit intrusion and a more comprehensive rule is under consideration. This is FMVSS 208 which seeks to limit occupant injuries under the following crash conditions:

Frontal barrier crash at 48 km/h (30 m.p.h.)

Lateral moving barrier crash at 32 km/h (20 m.p.h.)

Rollover at 48 km/h (30 m.p.h.).

In Australia, ADR 22 requires head restraints to withstand rear impacts involving seat half-sine acceleration of 8 g for 80 ms; FMVSS 202 makes similar provisions. These imply a minimum velocity change of 15 km/h (9 m.p.h.).

The pulse shape resulting from a barrier crash will depend upon the type of crush structure incorporated in the front of the vehicle in order to pass the ADR 10B test. Since the test requirement in this Rule is a maximum horizontal displacement of 127 mm (5 in), common to all vehicles, similar deceleration pulses would now be expected in most cars. It is understood that a 20 g half-sine pulse of 100 ms duration now reasonably represents many cars in front barrier crashes. Incidentally, a 48 km/h front barrier crash is identical in its effects on the vehicle and occupants to a head-on crash with an identical vehicle (or, more correctly, a mirror-imaged vehicle) of identical speed in the opposite direction (a closing speed of 96 km/h).

We elected to use a pulse intended to produce assembly loads not exceeding the design strength nominated in the Australian Standard[1]. We based our sled pulse on knowledge of actual car pulses and degraded velocity change to 40 km/h (25 m.p.h.). The objects of the crash simulations were:

- To see if dynamic effects produced component fracture when the total deceleration force was within or near design limits.
- To study the kinematics of crash simulations: in particular the potential for ejection, for submarining (displacement of torso beneath the harness) and for undue excursions from seated position.

- To examine the locations of major restraining forces on the dummy (simulated child occupant).

Although we were aware of deficiencies in the dummies available for the work, we elected to use commercial dummies representing 3 year and 6 year old children, knowing that the work should indicate directions in which improvements to dummies should be made.

FIELD DATA

The accident data available in Australia for restrained children are much too sparse to be useful. Manufacturers estimated that about 80,000 SAA-approved child restraints for the 1 to 4 year age group were sold in the twelve months July 1972 to June 1973 yet, in spite of the assistance of the Police, the public and manufacturers, we have only recorded two instances where SAA-approved devices failed to achieve their objectives. In one case a 16 month old child was ejected without injury from a seat-with-harness when the brake was applied; this was traced to loose fitting of shoulder straps and interference by the occupant with these straps which were pushed off the shoulders. The other concerned a violent side impact resulting in a fatality, once more involving loose fitting of shoulder straps, this time to an even younger child. Many reports have been received, mainly by manufacturers, of good performance. We are taking steps to increase the field data available to us concerning the performance of child restraints.

Studies in South Australia have given a breakdown of injuries to unrestrained passengers in the paediatric range. Of the injuries sustained by these children, 91% involved the head, including the face. 10% of the head injuries were of a serious nature i.e. cerebral injury and/or fractures of the skull. Internal injuries involving the thoracic and abdominal cavities rated 5.1% of the injuries sustained[11].

PRACTICAL APPROACHES TO CHILD RESTRAINT

All the crash-worthiness needs of a restraint are normally achieved by "catching" the child, shortly after he starts to move towards a collision, with either padded surfaces or flexible straps or a combination of the two. Surfaces and straps each have their particular advantages. The hot climate may be partly responsible for Australian manufacturers having selected the cooler alternative of straps for forward restraint in all approved restraints. The Australian Standard[1] does not demand this approach. Overseas, manufacturers have obtained acceptance for restraints that rely much more upon padded surfaces. Padded surfaces have the advantage of giving some protection to the passenger against sharp points or edges intruding into a crashing vehicle and can be designed to allow more uniform deceleration of the passenger. Some Australian restraints incorporate padded surfaces intended to resist sideways movement. They rely upon a padded back or the seat squab for restraint during rear impact and utilise the seat on which the child sits to resist downwards and some horizontal movements. Provision of side and rear protection is not yet a mandatory requirement of the Australian Standard.

The harness approach to restraint, found in all SAA-approved child restraints, is partly derived from the adult lap/sash belt which has already proven effective in Australia[20], and other more complicated harnesses. Before examining their adaption to children, we should consider the application of seat belts and harnesses to adults.

(a) Lower Torso Restraint

A lap strap, lying across the pelvic girdle, is relied upon for the deceleration of the lower half of an adult when he is restrained by a lap/sash belt. We believe that the lap strap in the unloaded condition should be at the level of the pubic symphysis in order that under crash conditions the deceleration forces will be applied to the superior pubic rami and the anterior iliac spines. This is illustrated in Figure 3.

(b) Upper Torso Restraint

One or more sash or shoulder straps are usually used to distribute deceleration forces across the thoracic cage, and hence prevent excessive forward travel of the upper parts of the occupant. These straps are typically attached to the lap strap which, in a crash, may thus be pulled above the pelvis and injure the abdominal organs or the lumbar vertebral column. Snyder[2,3] has proposed the connection of sash or shoulder straps to the floor; we believe that they should not be attached to the lap strap unless measures, such as provision of a crotch strap, are taken to limit lap strap movement.

(c) Head Restraints

The need to limit hyperextension of the cervical vertebral column is well established and has resulted in mandatory provision in Australian new cars of head restraints for protection in rear impacts. Many current designs appear however to be ineffective when acceleration direction is not close to the longitudinal axis of the car. Head restraint appears to be unnecessary in frontal crashes, the chin impacting the manubrium sternum and safely decelerating the head. If however the upper torso is inadequately restrained in frontal crashes, impact of the head with the interior of the car can result in hyperextension.

PECULIARITIES OF THE CHILD

It has been asserted by many researchers that children's body dimensions, proportions and bio-mechanical properties are so markedly different from those of adults that a child cannot be considered simply a scaled down adult[4,5,6,7,8,9]. The various parts of the body do not maintain the same relative proportions from birth, but develop in a sporadic and non-uniform fashion; thus mass distribution, size and shape differ from the adult. Also, the child does not have the adult's massive body structure and thus cannot resist the same crash loadings. On the other hand, the smaller mass of the child signifies proportionally lower deceleration forces compared with adults in the same crash.

(a) Head and Neck

The size and mass of the head of a child are larger in proportion to its torso than those of an adult. At birth, the child's head is one quarter of the total body length, whereas in an adult it is one seventh. The facial portion of the head at birth is considerably smaller than the cranium, having a face to cranium ratio of 1:8 (compared with the adult ratio of 1:2.5[2] and the face remains tucked below a relatively massive brain case even up to the age of 6 to 7 years. At this age, coinciding with the eruption of the second dentition, the rudimentary maxillary sinus grows considerably and the baby face elongates and takes on more adult contours[8]. The skull of the infant consists of a loosely connected system of flat bones formed from membrane matrix and cartilage. Infant and child skulls are very pliable because of this segmented arrangement of skull bones and the flexibility of the individual bones.

The factors that contribute to head impact problems with children are:

(1) the relatively large size and mass of the head,

(2) the relatively soft, pliable and elastic bones of the cranial vault,

(3) the existence of the fontanelles between the cranial bones.

These features make a child's head relatively less resistant to impact than an adult's head. We were unable to find any quantitive evidence of the tolerance limits of a child's head in impact trauma.

The necks of children are relatively more slender, weaker, and shorter in both muscular and skeletal structures than the adult neck. The child's neck has to support a head which is proportionately larger and heavier. Indeed the head cannot be supported or controlled until 3 to 4 months.

(b) The Thoracic Cage

The chest of the infant and small child may be less able to resist collision loadings than that of the adult. The paediatric thoracic cage is thinner and the ribs more elastic[2,9] permitting relatively large deflections of the thoracic cage with the attendant possibility of damage to the proportionately larger organs within the thorax. No thoracic impact data have been found by us for children.

(c) The Abdominal Cavity

The abdominal cavity is one of the most vulnerable portions of the human body. When standing erect the abdomen is adequately protected from behind but very inadequately protected from the frontal aspect. The proportionately larger abdominal viscera of children also make them potentially prone to frontal trauma. One study[11] has indicated that in the general accident scene, after cerebral injuries and burns, abdominal injuries are most common. Thus, it appears that blunt abdominal trauma can be potentially serious to children, because of their immature structure, large organ relationships and limited muscular-skeletal protection. We were unable to locate specific data on paediatric abdominal trauma in restrained automobile occupants.

(d) Pelvis

The pelvis in a small child is relatively smaller than that of an adult. The adult pelvis has prominent iliac crests whereas in a child they are under-developed, and have rounded contours. These crests do not become significant until the age of 9 or 10, and secondary ossification centres do not begin to form until about the age of 12 (girls) and 13 to 14 (boys). These features make it more difficult to keep a lap strap in contact with the undeveloped pelvis of the young child.

The curvature of the child's spinal column adds to the problem of locating a lap strap. The very young child has marked primary curves and little or no secondary curves. The cervical curve (a secondary curve) is not fully developed until the first year and the lumbar curve is not developed until 12 to 18 months or when the child has attained the upright stance. The lack of secondary curvature in the lumbar region of the spine means that the child's pelvic inlet is not tilted forward to the same extent as the adult's, and this increases the "submarining" potential of the child's pelvis. The potential is increased if the normal "slouched" seating position of the child is maintained. Under crash conditions, therefore, the child's pelvis is especially prone to submarining under a lap belt, resulting in deceleration forces being applied to the abdominal cavity instead of the pelvis.

(e) Subcutaneous Tissue

Subcutaneous tissue or body fat of a child is a complicating factor in restraint design. From birth to 9 months of age, this fat grows rapidly but thereafter the growth rate decreases so that at 5 years of age the layer is about half the thickness of that of a 9 month old child. This fat layer often produces bulges of flesh around the bony structures of the child and can prevent or make difficult the proper positioning of restraining straps during impact.

(f) Behaviour

The awareness of children to the dangers of riding in an automobile is often negligible. A child is not likely to stay still on the back seat of a car but is more likely to take a genuine interest in the changing environment round him and express his interest with a certain amount of physical activity. Parents are concerned about the avoidance of an accident in the first place[10], and the confining of a child by the use of a safety restraint lessens the risk of distraction by misdirected play activity.

PART II

DETAILS OF EXPERIMENTAL CRASH SIMULATIONS

Several reports have been published of research into, and dynamic tests of child restraints in other countries[7,12,13,14,15,16,17,18]. Their results however cannot be directly applied to the Australian restraints because of differences in testing techniques and parameters, and in the design of restraints, vehicles, and vehicular components. The tests described in the following sections of this paper were designed to fill the gaps in our knowledge.

TESTING EQUIPMENT

The crash simulations to be described were carried out on a Monterey rebound-type crash simulator capable of producing 50 km/h velocity change with a 700 kg payload. The source of propulsion in this sled is a set of 3 elastic shock cords which provide pre-crash sled acceleration in the range 5 to 15 m/s^2 (0.5 g to 1.5 g). In the work to be described the minimum single cord arrangement was used with an acceleration of about 5 m/s^2 (0.5 g), in order to minimise disturbance of the dummy prior to impact.

Preliminary frontal tests were conducted using a two-door Morris Mini body shell. This car has a four-seat layout and a flat floor, well suited to anchoring to the sled platform with a minimum of bracing. Testing of child restraints approved by the SAA was performed with the restraint anchored in the rear compartment. Non-approved devices were tested, in front or back, depending on the manufacturer's instructions supplied at point of sale.

Tests in the Mini provided valuable insight into practical problems of restraint systems but severely limited observation of dummy movements, even when the car doors were removed. Accordingly an open rig was constructed for all other tests, using the rear bench seat from a 1968 model HK Holden four-door sedan. This rig could be mounted on the sled so that the normally seated passenger would face 0°, 45° or 90° from the direction of travel in order to simulate head-on, front corner and side

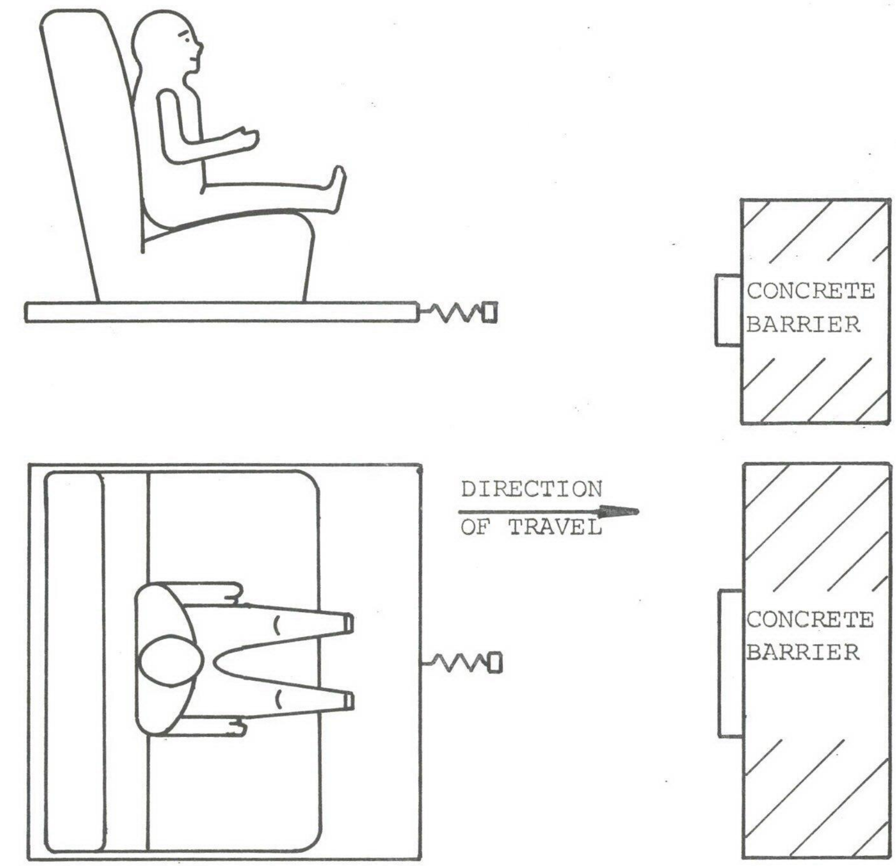


Figure 4a

Rig arranged to simulate head-on collision, passenger facing 0^{o} to direction of travel.

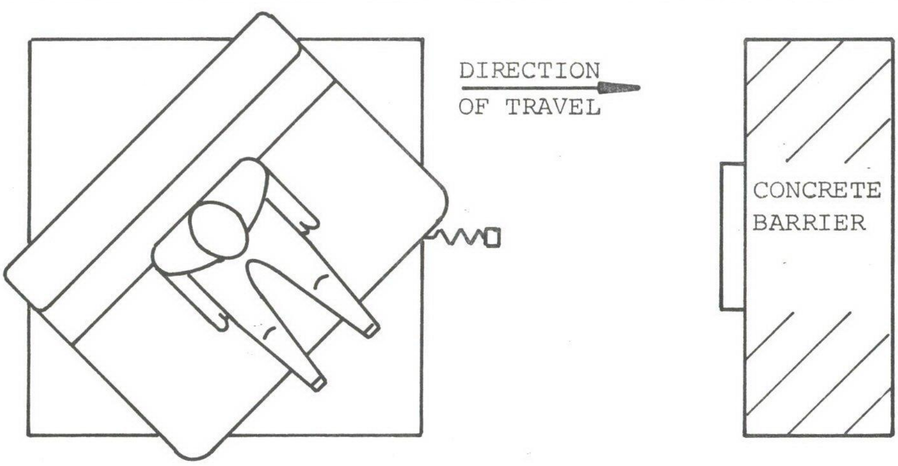


Figure 4b

Rig arranged to simulate front left corner collision. Passenger facing 45^{o} to direction of travel.

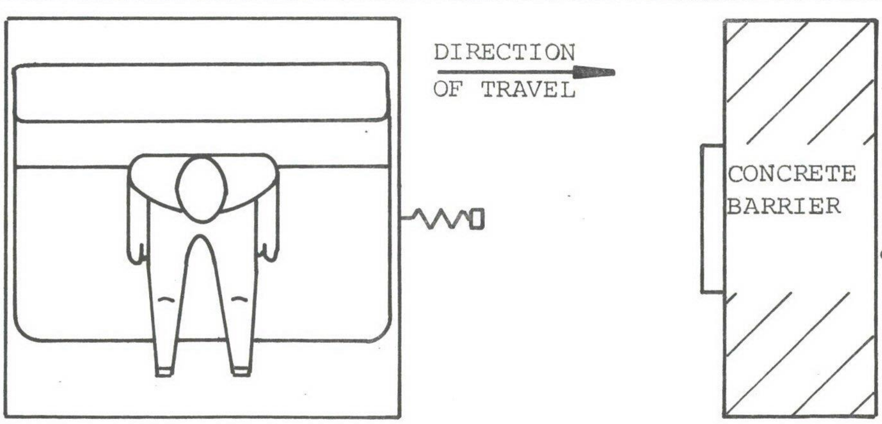


Figure 4c

Rig arranged to simulate left side collision. Passenger facing 90^{o} to direction of travel.

collisions. Figures 4a, 4b and 4c indicate the layout during these simulations. Figure 5 illustrates a typical test arrangement on the sled platform.

For the preliminary tests on the Mini, a sled-mounted camera rode the deceleration with the car body shell. For the main tests, ground-mounted cameras were used with calculated compensation for the movement of the rig and for the distances of the various parts from the cameras. The photography and subsequent analyses were designed to give estimates within 25 mm of actual.

Measurements of acceleration were based upon a factory-calibrated accelerometer of the strain gauge type. The accelerometer was mounted on the stiff floor of the sled and was checked with other factory calibrated accelerometers mounted alongside and with an accelerometer mounted on the parcel shelf. A typical graph is given in Figure 5. After filtering to SAE J211 class 60, the peak accelerations were measured in the range 152 m/s^2 to 187 m/s^2 through the three main test series with a mean of 170 m/s^2 (17.3 g). The duration above 10% of peak ranged 93 to 103 ms with a mean of 99 ms.

Changes of velocity were estimated by integrating the acceleration record between the zero crossings. Comparisons were made with the integration from the other accelerometers and with the sum of the approach and rebound velocities indicated by a stroke transducer connected to the sled from the impact block. Estimates ranged from 35.8 km/h to 41.8 km/h with a mean of 38.6 km/h (24 m.p.h.) during the three main test series.

Webbing forces were measured with compact transducers specially designed for the light loads and narrower webbings of child restraints, and with heavier transducers for the 50 mm webbing of adult restraints. In these transducers beams carrying strain gauges are deflected by the webbing as it passes over rollers. The special transducers were arranged for minimum sensitivity to the tensions in the webbing between the rollers because experiments had indicated that friction between webbing and rollers left these tensions significantly out of phase with the tension in the remainder of the webbing. Nevertheless some sensitivity

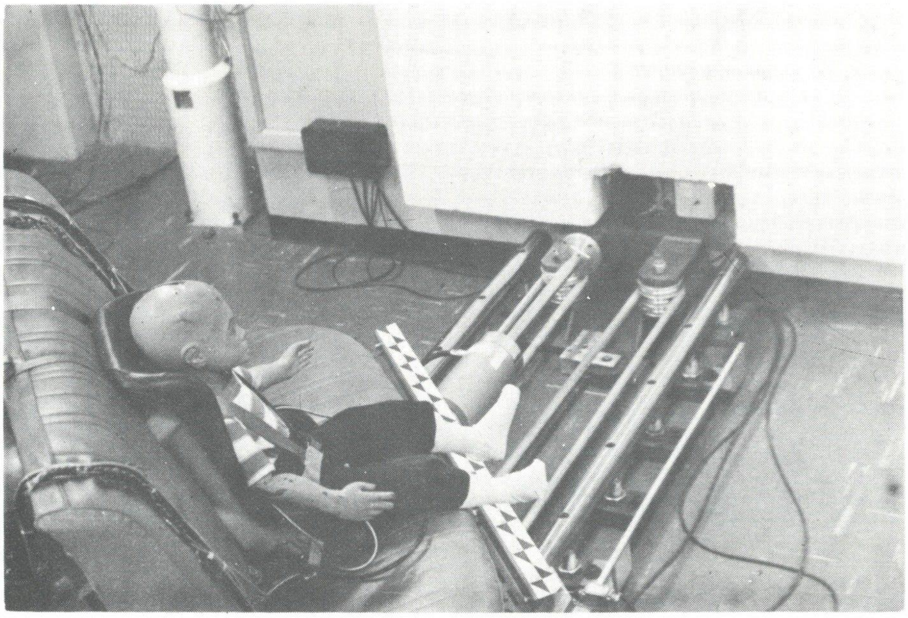


Figure 5. Open rig arranged for 45° test. TARU Negative 307-03

to the inter-roller tension persisted and the compact transducers were calibrated and used with confidence only as maximum force indicators. Typical webbing force plots are included in Figure 6.

In most tests, a Sierra 492-03 "Toddler" dummy was used. A Sierra 492-106 "Sammy" was used for testing harness systems intended for large children. A brief summary of these dummies is given in Table 1.

Table 1. Anthropometry of Dummies

	3 Years Old "Toddler" Sierra 492-03	6 Years Old "Sammy" Sierra 492-106
Mass	14.2 kg	23.0 kg
Standing height	0.955 m	1.165 m
Alterations	Vinyl "flesh" cut from knees and ankles to facilitate realistic limb positioning and kinematics	None

Anterior/posterior decelerations were measured at the centre of the head and in the thorax during preliminary tests. The results of these acceleration measurements were relatively independent of the child restraint used, and we found cinematography and webbing force measurements to be of greater use in the appraisal of restraints. Dummy decelerations were not measured in the main tests, the measurement emphasis being directed at ascertaining the space requirements and restraint forces and geometries.

TEST PROGRAM

The preliminary test series was aimed at exploring superficially the dynamic performance of all child restraints then available to the Australian public. Tests were carried out in the Mini car shell with

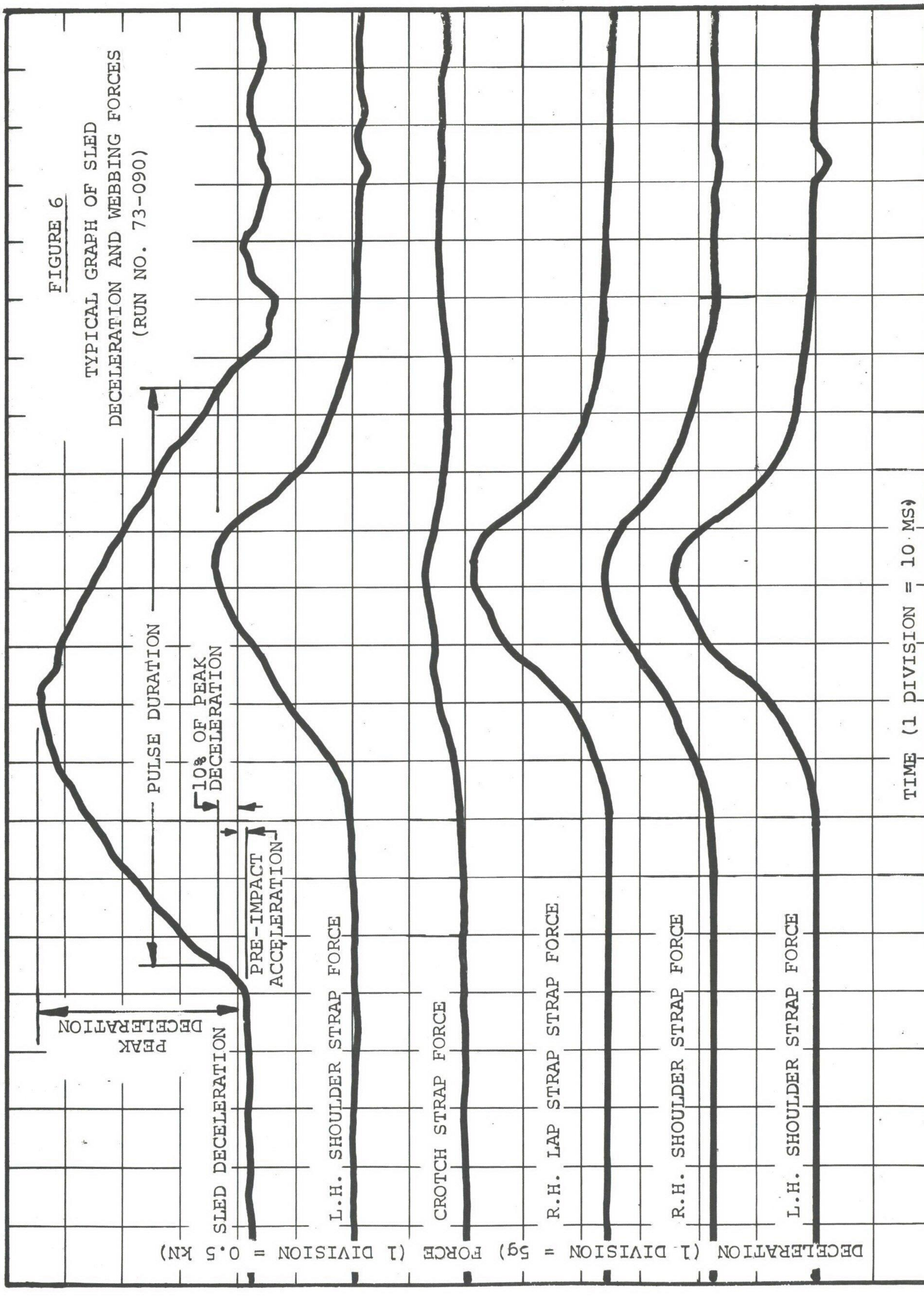


FIGURE 6
TYPICAL GRAPH OF SLED DECELERATION AND WEBBING FORCES (RUN NO. 73-090)

decelerations similar to those reported for the open rig, and with the dummy facing the direction of travel.

Ten devices were tested in this preliminary work. The series confirmed AS E46 gravitational test results by indicating satisfactory performance by, and only by, the six approved restraint systems. The unsatisfactory aspects of some of the unapproved devices are discussed later in this report.

Acceleration of the passenger compartment during a collision involves a complex history of forwards, sideways, and upwards linear accelerations, and roll, pitch and yaw angular accelerations. The preliminary tests followed the usual practice of examining the behaviour of devices when only the forward acceleration is present. The main test program extended this to an examination of the effect of the sideways acceleration which is encountered in many intersection and skidding collisions. The open rig was used, and was mounted to face the passenger at 0^{o}, 45^{o}, or 90^{o} to the collision deceleration.

An anthropomorphic dummy representing a 50th percentile, 6 month old child was constructed. This dummy was not completed in time to permit any dynamic crash simulations to be included in this report but a series of wearing trials was conducted for SAA-approved child seats. These trials are reported in the relevant appendices. Some implications of the trials are discussed later in this report.

Approved Restraints

The SAA-approved restraints that were tested are collected for discussion purposes into three groups:

Framed seats:

- Micklem 694
- Steelcraft C54

Bucket seats:

- Britax B335
- Safe-N-Sound X4
- Safe-N-Sound KL
- Steelcraft C57

Harnesses:

- Britax B336
- Britax B338
- Safe-N-Sound SS150

Descriptions of each of these nine devices are given in Appendices 1 to 9.

Unapproved Restraints

The unapproved devices that were tested were divided into four groups:

Bucket seats:

Volvo

G.M. Loveseat

Framed seats:

Steelcraft C52

Steelcraft C45

Padded enclosures:

Guardwell CS200

Harnesses:

Clippa-Safe Trainer

Clippa-Safe Pilot

Micklem 725 lap belt, 710 shoulder harness, 715 booster cushion.

Adults' lap belt

Adults' lap/sash belt

Descriptions and illustrations of these devices are given in Appendices 10 to 18.

The "3-year old" dummy was used to test all of the approved devices except the Britax B338 and the Safe-N-Sound SS150. These restraints are approved for larger children and were tested with the "6-year old" dummy. The "6-year old" dummy was also used to test the performance of adult lap and lap/sash belts in restraining young children. All tests of unapproved devices utilised the "3-year old" but in the case of Clippa-Safe Pilot, Micklem 725/710 and Guardwell CS200, they were supplemented by simulations using the "6-year old".

Devices were initially tested with straps located as low as possible on the lap, and adjusted as tightly as was considered to be acceptable to a young child. The tests were then repeated "loose" with an arbitrary 75 mm of slack introduced at each adjuster of the restraint system and its anchoring straps.

During some of the "loose" tests at 45° and 90°, the dummy fell as much as 30° away from vertical as the rig accelerated towards the simulated collision in spite of the fact that acceleration was restricted to 5 m/s^2 (0.5 g). In these cases, the nearside shoulder strap slipped down and during the impact it loaded the dummy's upper arm instead of its shoulder and neck.

Our experience of dynamic testing is that experiment reproducibility is generally not significantly enhanced by renewing restraints when obvious damage cannot be seen. Accordingly, devices were inspected between tests, and were only replaced with a new sample when damage was obvious or when the angle of the test rig was changed.

In cases where adult lap or lap/sash belts were used to connect devices to the car seat, the belt buckles were specially prepared (generally bound with tape) to ensure that the buckle would not open. This action was taken because the objective of the test program did not extend to investigating the properties of adult systems. It should be noted however that these buckles can receive unusual shocks when used in the restraint of the framed seats. A buckle of a lap/sash belt opened during a preparatory test of the Micklem 694.

TEST DATA

The appendices include tabulations of the results of the tests of approved child restraints on the open rig in the 0°, 45° and 90° directions respectively. They also report tests of adult restraints applied to children and of unapproved devices. The movements of the dummies have been reported in terms of the total space occupied by the child before and during the crash. The terminology is defined in

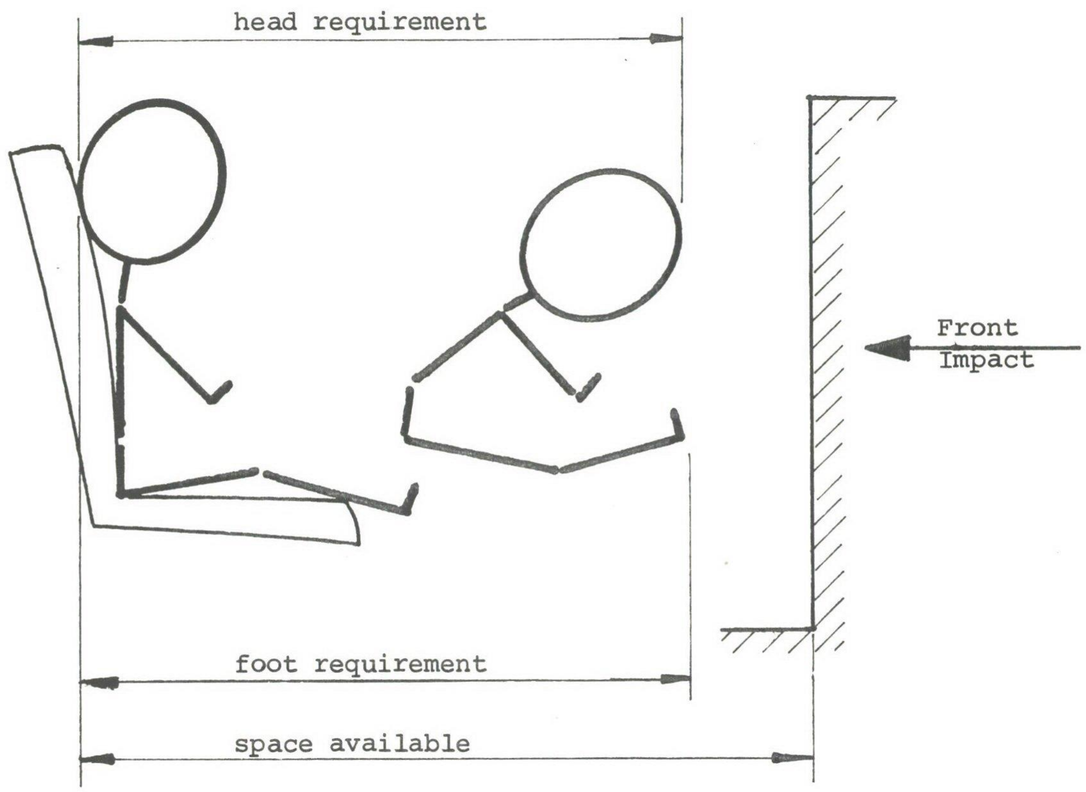


FIGURE 7A. FRONT IMPACT - TERMINOLOGY

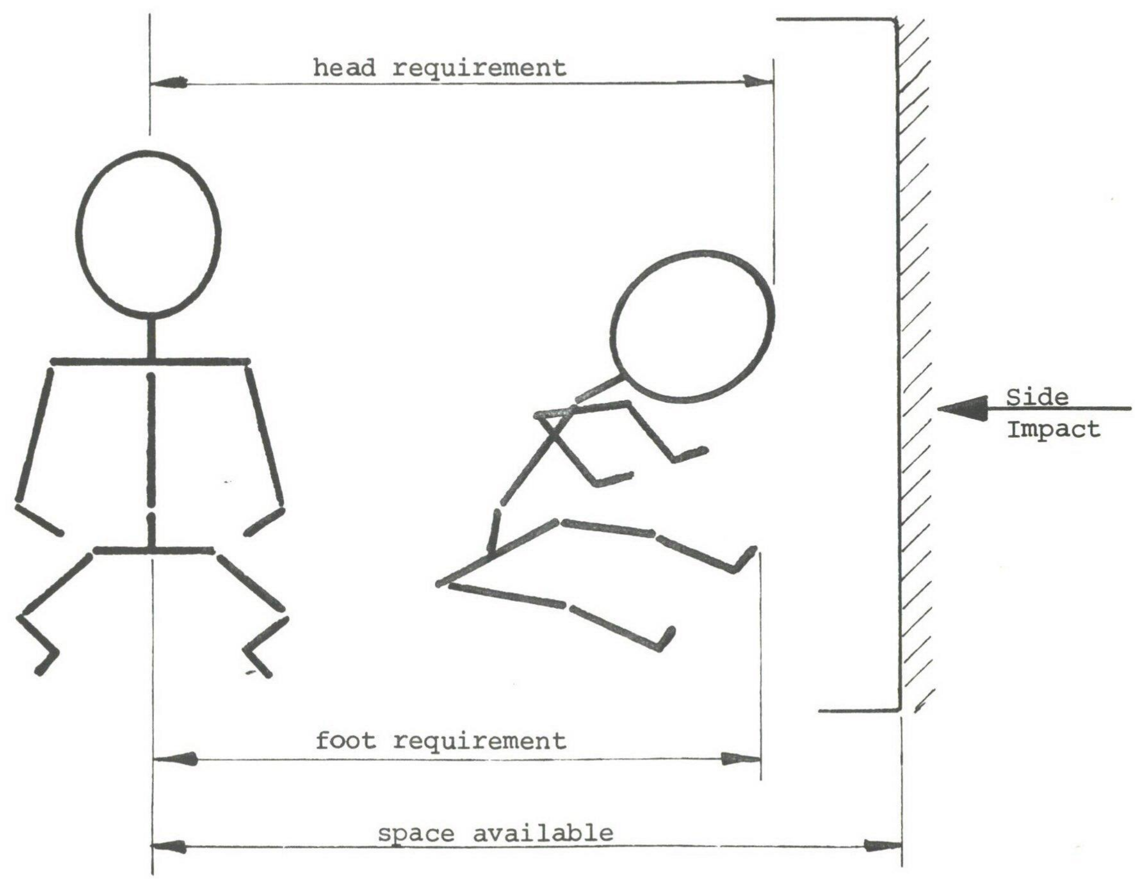


FIGURE 7B. SIDE IMPACT - TERMINOLOGY

The collision targets for children may conveniently be approximated by vertical planes across the car (for the dashboard or rear of the front seat) and vertical planes along the car for the doors and pillars). The space used by the dummy was, accordingly, described at right angles to these vertical planes to indicate the probability of collision.

In the forward direction, all estimates of necessary space were made from the pre-crash location of the dummy's back. These estimates therefore indicate the space needed in a car between the back of the seat on which the child sits and the seat or dashboard in front of him to avoid impact with the nominated part.

Sideways estimates of necessary space were made from the pre-crash location of the dummy's centreline. These figures therefore indicated the necessary space between the centreline of the anchorages of a child's restraint and the side of the car.

Upward movements were measured in the preliminary and 90° tests, but generally indicated little or no space requirement above the child's head. The tendency for some vehicles to roll during side impact, and for the car roof to accelerate towards the passenger during the latter stage of the collision, could make the space above the head important. Special simulation would be needed for exploration of this requirement.

Since the object of a child restraint is to minimise injury, the probable severity as well as the likelihood of a collision between the child and the car interior should be examined. This was not attempted from the film records of this test program, except to observe that in the 45° crashes, movement towards the side of the car was relatively gentle for the latter part of the collision. This movement occurred while the dummy was travelling towards the seat. As might be expected, the dummy moved from the seat towards the impact in the early part of each collision, but in no case did it spring back in the opposite direction, instead it swung around sideways towards the left side to come to rest against the back of the car seat. At the time this work was done our facilities for film analyses did not permit accurate estimation of the lateral space required to prevent impact of the occupant with the side of the car.

The measurements of space needed during collisions usually have been related to real cars by measuring the space available in the back seat of three car models. The results are summarised in the appendices. These measurements are only useful as indications of the amount of space available in undamaged cars when the front seats are adjusted fully back. In the 45° and 90° series, severe collisions with the side of the car were being simulated and with most current cars considerable intrusion would be usual.

OBSERVATIONS

In considering the test results, it should be observed that anthropomorphic dummies were used in place of the real children for which the devices were designed. The mass and major dimensions of the dummies are understood to be representative of children in the U.S.A. However the biomechanical properties must be expected to differ significantly from those of a real child and the following observations should be interpreted accordingly. Another restriction which should be noted is that our selection of anchorage points has been arbitrary, and would not necessarily apply in any of the cars to which we have related our measurements.

(a) Unapproved Child Restraints.

Some child restraints that did not have SAA-approval were included in the preliminary dynamic simulations with the Mini. These tests demonstrated several unsatisfactory aspects already noted[13,17] in other countries for similar devices. Several of these Australian restraints relied upon inadequate hooks to attach the seat to the back of the front passenger seat. In some cases, stronger hooks resulted in failure of the car seat mountings in 39 km/h (25 mph) impacts, the car seat joining the child and child seat in their journey through the windshield. Other unsatisfactory features of the devices without SAA-approval included inadequately padded horizontal steel tubes in front of the chest, some weak components, and harnesses without pelvic restraint or with closed loops which appeared likely to excessively load the stomach walls.

A further series of simulations was undertaken on the open rig. This encompassed all the unapproved devices available through major retail outlets in Sydney in December 1973 plus two imported devices not then available. Observations of the performance of unapproved devices are discussed in depth in Appendices 10 to 18.

The number of makes of each type of unapproved device was small so it was not possible to make general observations relevant to each type of unapproved restraint. It will be noted however that overall in cases where the dummy was contained, occupant excursions were often greater than for approved restraints and in some cases total ejection occurred either as a result of mechanical failure or inadequate anchorage of the device.

Many of the faults indicated by the preliminary test series were confirmed by this second series. Specifically it was found that 'hook over' seats did not necessarily cause the seat to collapse but instead, a sommersaulting action often occurred in the longitudinal plane where the device pivoted about its hooking point. In such a case, the occupant would have certainly impacted the vehicle roof. This effect was also noted in an unapproved device that was restrained by a parcel shelf strap only.

Four devices that had some measure of approval overseas, but did not carry SAA licence numbers when examined by us, are deserving of special mention, if only to examine them to see if they would be likely to gain SAA-spproval were they to be submitted to the Association.

(i) The Clippa Safe Pilot harness carried the BSI Kite Mark of approval. It, in our opinion, would be likely to gain SAA-approval providing it could be shown to pass the static loading test and harness ends were modified to prevent separation from fittings.

(ii) The Volvo child seat would be likely to fail unless the padding for the head were upgraded and the harness modified to prevent detachment. These appear to be matters that the manufacturer could rectify very easily. We were concerned in this case that the design location for this device is under the front windshield - a position which is known to be the most hazardous position in the vehicle in terms of intrusion.

(iii) The General Motors "Love" Seat would be likely to fail because the adult lap belt, used to secure it, could load the occupant's chest or abdomen; clearly this is very objectionable. The manufacturer could modify the installation procedure so that the belt passed around the seat base although it might be found that the base would need improving to make it a more secure anchorage.

(iv) Guardwell CS200. The Guardwell enclosure was said to comply with all U.S. Federal Safety Standards. It would not have met the requirements of AS E46 unless the padding which sometimes limits head movement were to be upgraded. It is also dubious whether restraint loads would be applied to pelvis and thorax of the occupant as required by AS E46; in our simulations it appeared that the restraint surface contacted the occupant's midriff.

In our opinion, none of these devices should be used until modified as indicated above.

(b) Approved Child Restraints

Tables in the appendices indicate the space requirements for the dummy; force measurements reported in the same tables indicate the peak tensions in those webbings that pressed against the dummy. The appraisal of the measurements was greatly assisted by high speed cinematography, and was made from anatomical and pathological points of view.

Observations that pertain only to particular devices are discussed in the appendices. Results general to the SAA-approved restraints were:

- None of the restraints allowed their dummy occupants to eject from the rig, even when they were loosely adjusted.
- When tightly adjusted, all of the SAA-approved child restraints kept the head and torso of their dummy passengers within the space that would be available had the restraint been mounted in the centre of the rear seat of a large sedan.
- Hands and feet of the dummies moved beyond the space typically available in Australian cars.
- During simulation of side impact, the excursions of the dummy were sufficient, with all the devices, to have brought the dummy's head and torso into contact with a car interior, had the restraint been mounted in the seating position on the collision side of a car.
- Except where loose adjustment caused the left shoulder strap to drop off the shoulder before impact, left shoulders received much higher peak loadings than right shoulders during the 45^{o} and 90^{o} left hand side impact. The tensions were as high as 2 kN (450 lbf) and, from observation of the film, were judged likely to apply about 1 kN (230 lbf) to the dummy's shoulder near the neck.
- The forces on the lower torso restraint, in contrast to the shoulder, were heaviest on the right during left hand side impacts. It was not feasible to deduce from the side impact force distribution whether the vertebral column was torsionally loaded. Nevertheless, twist of the dummy was recorded in the cinematographs, and torsional loading of the vertebral column remains a possibility.

(c) Adult Restraints Applied to Children

The results of dynamic tests of adult lap/sash and adult lap belts are detailed in the Appraisals 17 and 18.

Adult seat belts restrained their dummy occupants from ejection in these tests, and lap sections of the belts were in every case properly located near to the dummy's thighs with the anchorage geometry in use.

We observed two disadvantages of these adult systems relative to the SAA-approved child restraints. The first was the load developed in the stiffer webbing; 4.5 kN was measured in shoulder straps compared with a maximum of 3.4 kN for SAA-approved child restraints. We believe that the higher loads could lessen the benefits of restraint to young passengers. Greater space requirements by lap belts are the second, well known, disadvantage we found in the adult restraints. It was noted however that lap/sash belts restrained their occupant's heads and torsos sufficiently to prevent impact with the back of front seats, or with the car side which was furthest from them before collision. When located in the side seat, the lap/sash belt does not have sufficient space to prevent head and torso impact with the side in which the belt is fitted.

(d) Special Problems with Harnesses

Analysis of our crash simulation data yielded some observations that were applicable generally to all forms of child restraining devices that incorporated harnesses, particularly when applied to very young occupants. These related to harness adjustment; the use of booster cushions; submarining; shoulder restraint:

(i) Adjustment

Child restraint wearing trials were conducted using anthropomorphic dummies, and are reported in the individual appraisals in the appendices. It was noted that in some cases, when the occupant was in position in an installed child restraint, it became very difficult to gain access to the harness adjusters. Indeed, it was sometimes necessary to release the top anchorage of a child seat in order to gain access to shoulder strap adjusters on the rear. This would have precluded correct adjustment in many real-life installations. In some cases where the adjusters were accessible, the nature of their operation inhibited ready variation of their setting. Figure 8a shows the arrangement of one adjuster which was considered particularly difficult to operate. Similarly Figure 8b illustrates an adjuster which could be manipulated with ease. The greatest measured webbing slip during crash simulation was similar in each case. We were unable to predict creep during normal wearing.

(ii) Submarining

Submarining is a term applied to a sequence of events during an impact in which the occupant slips beneath the lap belt of his restraint harness. As a result of this displacement, the lap belt loads are no longer applied to the rigid pelvic structure but to the internal organs of the lower abdomen. Some degree of submarining was observed several times during our crash simulations. It appeared to be related to harness geometry and, in the case of child seats, to the stiffness of the seat cushion and its supporting structure. The effect of booster cushions is discussed below.

In some cases, high crotch strap loads were recorded when the dummy's torso contacted the strap. We considered these loads to be an indication that the omission of the strap would have permitted the occurrence of submarining.

It seems that, in child seat harnesses, submarining might be more likely in seats with high lap belt anchorages and steep sideview lap belt angles. Submarining appeared to be initiated by tightening of the shoulder straps which then lifted the lap belt upwards. A tight crotch strap tended to resist this lifting. In some cases it was possible for the cushion to compress the seat base structure to deflect under the downward component of lap belt load; this appeared to enhance the possibility of submarining.

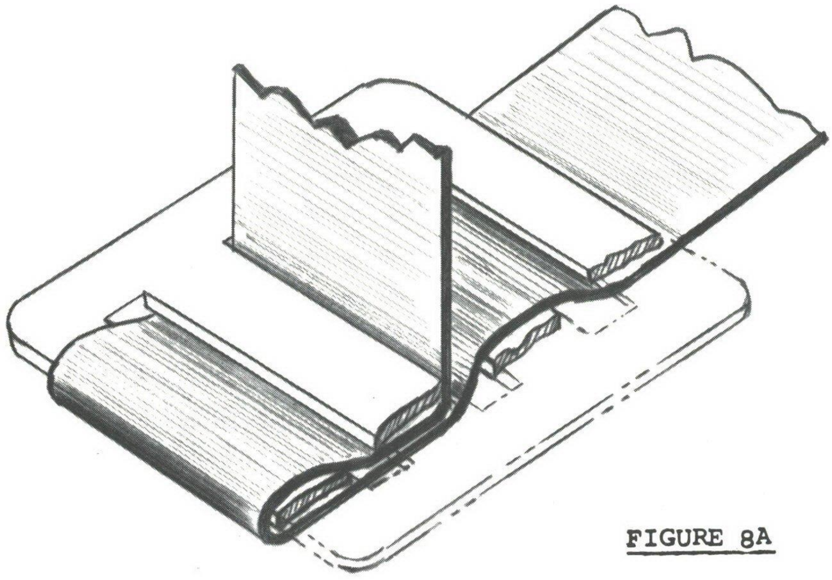


FIGURE 8A

FIGURE 8

TYPICAL ADJUSTERS

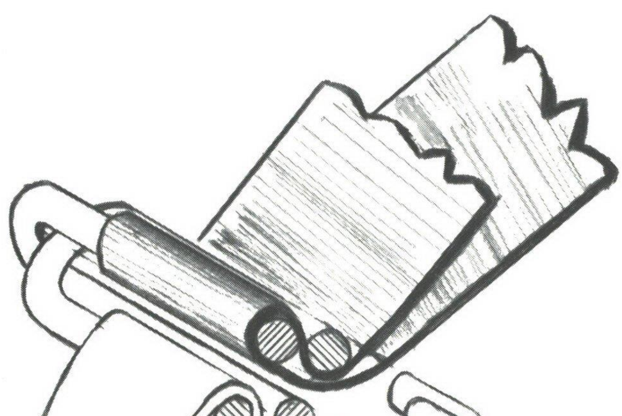


FIGURE 8B

We noted however one child seat that was not fitted with a crotch strap but which displayed very little tendency for its occupant to submarine. This seat, the Micklem 694, had long lap straps with anchorages well below and behind the seat intersection point. Sideview lap belt angle was moderate (approximately 50^{o}), and the seat base was well braced at its leading edge. We are currently subjecting the mechanism of submarining to further research.

iii) Booster Cushions

"Booster" cushions are used to elevate the child occupant of a vehicle seating position often to allow him vision through the vehicle's windows.

Two types of booster cushion were evaluated in conjunction with child harnesses, one relatively firm but heavy and unrestrained, the other light and restrainable but very soft. It was noted that both cushions were associated with the occurrence of submarining but in different ways. The firm cushion ejected and permitted the dummy to fall beneath the harness; the soft cushion simply compressed. We could not state whether restraining the heavier cushion, by attaching it to the harness, would have contributed significantly to the webbing forces, although plainly such contribution would be undesirable.

(iv) Shoulder Restraint

Although our simulations showed that all SAA-approved devices restrained the upper torso of the relevant Sierra dummy, we did note that such restraint was marginal in side impact and when the shoulder harness was loosely adjusted.

We noted during trial installation of a dummy representing a six month old child, that shoulder straps of approved devices were generally too widely spaced. Shoulder straps were found to contact this dummy at the acromion (the outermost point of shoulder joint) and then to run down the chest, contacting it only at its sides. This arrangement was further degraded by the existence of slack in the webbing, a condition which we consider to be common in normal use. It appeared to us that such an arrangement would not provide adequate shoulder restraint for the very young child, though we have not yet verified this assumption by crash simulation. We have previously described, under "Field Data", two actual cases in which a very young child was ejected over the lap belts of approved restraints.

We assumed that the lateral spacing of shoulder straps was usually selected by the designer as the minimum necessary to comfortably accommodate an occupant of maximum approved mass. Such spacing was not normally adjustable and hence there was an apparent lack of restraint in the case of the very young child.

Pending research into methods of modification for child restraints, to render them more habitable for the very young child, we developed a device to re-route the shoulder harness such that it could be made to provide maximum contact with the upper torso. It consists of a flexible plate which snaps over the shoulder straps between their anchorages and the occupant's shoulders. A sketch of the harness guide and a photograph of a typical installation are presented in Figure 9. It will be seen from the illustration that the guide could be fitted without any modification of the child restraint; once fitted, no adjustment was required.

A simulation was conducted to evaluate the harness guide. It utilised the Unit's six month old dummy in a Safe-N-Sound 'KL' approved child seat. The shoulder straps were set to the upper anchorage position and 3 inches of slack were provided in each. The shoulder straps were found to be kept in contact

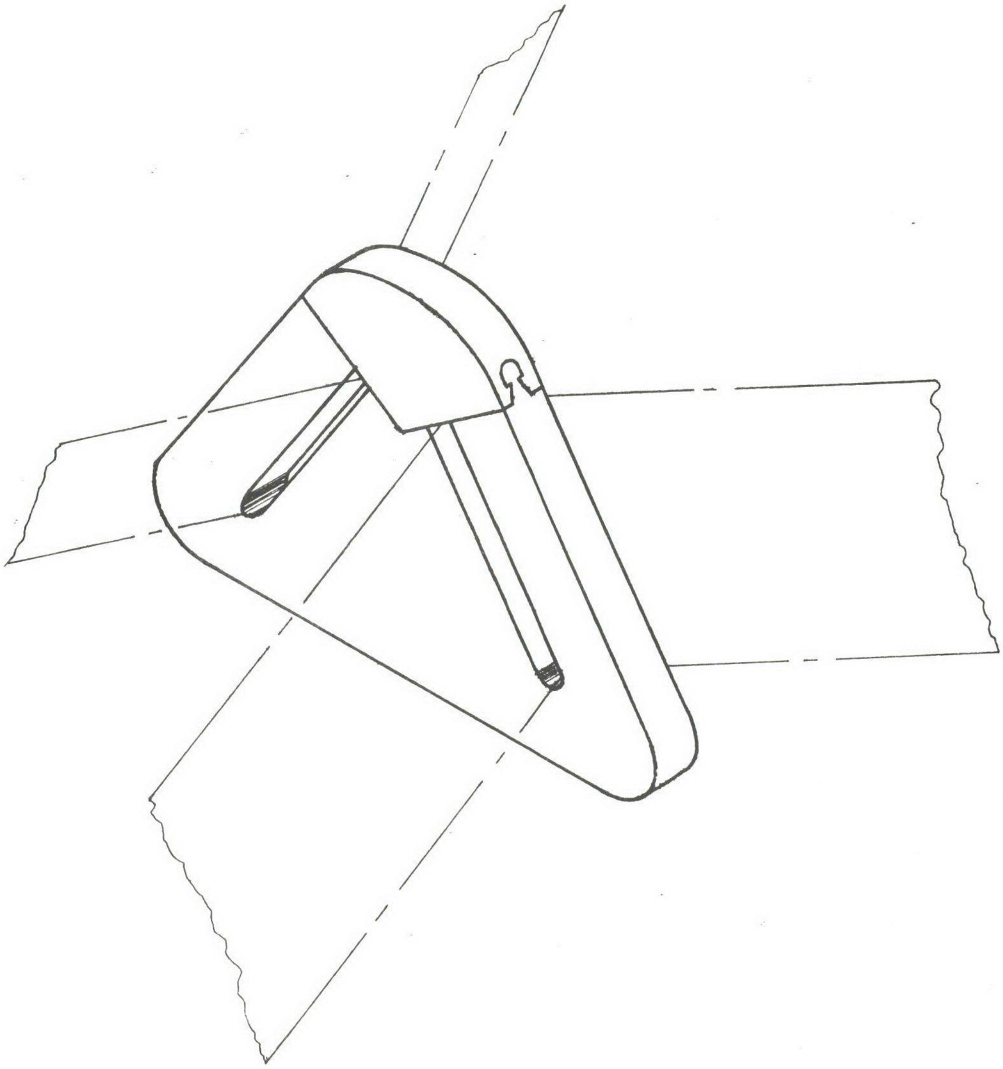


Figure 9 Child Restraint Shoulder Harness Guide.

TARU Negative 435-33

with the dummy's torso throughout the crash sequence. A comparison simulation with the harness guide omitted, did not allow complete ejection of the torso but showed much greater spacing between the straps. In the latter case the loads were applied to the upper arms. Had the dummy the human ability to 'shrug' its shoulders, it is probable that the torso would have become unrestrained.

It should be noted that this discussion of shoulder restraint has been aimed primarily at harness with parallel shoulder straps. An alternative to this arrangement was observed on one approved device, the Safe-N-Sound Model X4, and one unapproved device, the GM Love Seat. This was the arrangement of the shoulder straps in "Vee" form, meeting at the lap belt centre buckle. This arrangement appeared to us to offer potentially superior shoulder restraint, since its straps were naturally kept to the centre of the chest. In these particular cases it could have been improved still further for the small child by fitment of our harness guide.

It will be noted that we have not suggested the use of a horizontal chest strap to hold the shoulder straps in place. This is because, in some of our simulations, with a harness that included a chest strap, submarining occurred to such a degree that the dummy came to rest with the chest strap contacting the neck just beneath the chin. Although we were unable to predict possible injuries to an occupant in a similar real crash situation, we felt justified in rejecting the chest strap as a solution to the problem of providing a desirable shoulder strap arrangement.

(e) Anchorage problems

Our crash simulations provided strong support to the requirement of AS E46 for a minimum of three anchorage points in the vehicle for any child restraint installation. This requirement is of course shared by adequate restraints for adults. They also supported the AS E46 requirement that, viewed from ahead, the centre of mass of the child occupant should appear to be close to the centroid of the triangle formed by the three anchorages.

By employing an existing lap/sash belt to anchor a child seat, the need to provide any additional anchorage can be avoided. In the future however, retractors will become mandatory equipment for front seat lap/sash belts and are already appearing in all outer seats of some cars. Locking retractors currently being installed in Australian cars have been shown in our crash simulations to lock quickly under 0.5g braking conditions and in 17g frontal crashes when worn by adult anthropomorphic dummies. We have not yet performed crash simulations with child seats anchored by retractable belts and must express some doubts about such procedures until supporting evidence becomes available from further research soon to be undertaken.

Many child restraints make use of lap belts provided for adults in centre rear seats. These will not be affected by retractors, unless for example, taxis are required to have retractable lap/sash belts in five seats, which appears practicable.

Other child restraints require the attachment of special anchoring fittings to the car seat pan. This sometimes involves drilling the seat pan or removal of the lap belt (which can then sometimes be replaced) for access to the original floor anchorages. No great objections can be seen to these practices, from an engineering viewpoint, provided that the work is performed competently but both could be viewed as undesirable, and are possibly illegal in some Australian States. It would clearly be preferable for convenient and accessible floor anchorages to be provided by the car manufacturer in each rear seat position.

Similar arguments apply to the parcel shelf and the question of the design of a universal fitting for such purposes arises. A universal fitting should permit transfer of child restraints from car to car, and the pre-existence of several sets of fittings should then aid the installation of child restraints for families that include several sub-teen children. Bassinet restraint also becomes feasible.

These appear to be matters for inclusion in Australian Design Rules in the immediate future.

(f) Anchorage for car seat back and cushion

In our simulations where a child seat was secured by an adult's lap/sash belt, the car seat back was assumed to be restrained in the crash, so that it should not strike the back of the restraint and overload it. In the case of child harnesses and child seats with their own anchor straps, no such restraint of the seat back is provided and reliance has to be placed on the car manufacturers' assurances, on Australian Design Rule 3, or on a supplementary seat-back restraint as specified in AS E46. For cars manufactured since 1970, ADR 3 requires all seats to be capable of sustaining a 20 g load without fracture; it would have been helpful to know that this included the seat cushion and seat back. The prospect of child wearers of harnesses being impacted by seat backs is not tolerable, nor is the fracture of child seat anchorage straps by overload.

(g) General

In spite of its limitations, dynamic testing revealed a number of important weaknesses, and indicated the distribution of webbing loads. Specification of greater strength and dynamic tests of components might reduce the need for dynamic tests of whole restraints. It would also appear possible to estimate space requirements statically, but the appraisal of strap geometry appears more easily and reliably achieved dynamically using high quality dummies, and as-yet-undeveloped objective measures of submarining.

Dynamic test observations applicable to individual models, are discussed in the relevant appendices.

PART III

CONCLUSIONS

CONCLUSIONS

1. Our crash simulations have shown that SAA-approved child restraints satisfy many of the requirements that we believe to be necessary for packaging people. We consider that an SAA-approved child restraint, correctly installed and adjusted, will afford a degree of protection sufficient to ensure survival of its occupant under frontal impact conditions almost as severe as those of our crash simulations - that is - in most real-life crashes.

2. Simulations have also shown that in general, unapproved devices do not offer an adequate level of protection. These devices are sometimes prone to structural failure under crash conditions and some types can easily separate from the vehicle structure. In simulations where the occupant of the device was restrained, the space requirements of unapproved devices included the presence of hazardous structural components in the occupant's survival space, and poorly designed harness geometry.

3. Four devices, not yet approved by the SAA, could easily be modified by their manufacturers to make them acceptable. These are the GM 'Love' Seat, the Volvo, the Micklem harness and the Clippa-Safe 'Pilot' harness.

4. We consider the introduction of AS E46-1970[1] to have been of value in improving the performance of Australian child restraints. There are, however, aspects of SAA-approved child restraints that could be improved. These relate to harness adjustment, shoulder restraint and pelvic restraint; they assume particular importance in the case of the very young child.

(a) Harness Adjustment

It is difficult to express a requirement for ease of adjustment but, at least, we would expect adjusters to be readily accessible, after the occupant has been placed in position. Plainly, the risk of ejection is heightened if the harness is not sufficiently tightly adjusted. Correct adjustment can only be anticipated with confidence if the adjusters are accessible and simple to operate.

(b) Shoulder Restraint

Our simulations did not reveal any case in which an SAA-approved child restraint failed to restrain the upper torso of either of the dummies used. We are concerned however that such restraint might be marginal for a child at the lower limit of the approved mass range. This is suggested by our fitting trials utilising a "six month old" dummy and by a subsequent simulation, and arises primarily from excessive lateral spacing of the shoulder straps in relation to the small child. We consider further research to be necessary in order to identify this problem and to devise effective countermeasures. (An interim solution has been presented in the text).

(c) Pelvic Restraint

Submarining of the dummy was observed to varying degrees during our crash simulations. We consider that submarining is primarily a function of harness geometry, although in some simulations, using unapproved restraints, it was initiated by collapse of the seat base.

The role of the crotch strap in the control of submarining should be to hold the lap strap in position on the occupant's pelvis. We have observed cases, during our simulations, where the crotch strap provided a direct physical barrier to forward motion of the torso. We have not established that this is a potentially injurious situation but we consider that a harness design should preferably inhibit submarining without applying deceleration forces to the occupant directly through a crotch strap. (We acknowledge the usefulness of a crotch strap as a measure designed to prevent a child wriggling out of a harness).

Further research is obviously necessary to enable the mechanisms of submarining to be more fully understood.

5. The occurrence of submarining and upper torso restraint problems were not as evident in our simulations as we had anticipated. We ascribe this lack of response to the nature of the anthropomorphic dummies used. At the time that our simulations were conducted, our smallest dummy was the Sierra "Toddler" which "fills" most harnesses quite well. We anticipate that future simulations, utilising the "TARU-Simon" ("six month old") dummy, will highlight these problems.

6. We consider dynamic crash simulation to be of value as a tool to be employed in the evaluation of prototype child restraints. It should not,however,be regarded as a "brute force" strength test, this being quite adequately provided by the existing AS E46 static loading requirement for the assembly; there does however appear to be a need to upgrade test requirements for individual components of assemblies. Dynamic crash simulation should rather be designed to permit an appraisal of occupant kinematics: the use of a representative anthropomorphic dummy is therefore essential. Dummies of the standard required are not readily available. We have found that repeated simulations can be carried out, subjecting the Unit's Sierra dummies to a half sine deceleration pulse of 17 g peak deceleration and 40 km/h velocity change. We commend this simulation as a suitable basis for evaluation of child restraints, but we qualify this by our reservations about Sierra dummies.

7. Sierra dummies would be of but limited value for appraisal of SAA-approved child restraints, if the requirements for a dynamic test were to be added to the current standard. Firstly, we do not consider either dummy to be sufficiently accurately detailed in its pelvic structure. Secondly, AS E46-1970 specifies two occupant mass ranges for child restraints and we consider these to be appropriate, namely: 9 kg to 18 kg; 18 kg to 36 kg. The Sierra "Toddler" has mass 14.2 kg, the Sierra Sammy has mass 23 kg. We are therefore unable to evaluate child restraints at either the upper or lower limits of their occupant mass ranges. We consider the "TARU Simon" dummy, of mass 8 kg, to be suitable for use at the lower limit of the range of child seats and that a suitable dummy should be designed for the upper limit.

8. The forthcoming introduction of retractors poses problems in regard to child restraining devices which are anchored by adults' seat belts. Research is needed to determine the efficacy of retracting seat belts for anchoring child restraints.

9. Universal anchorage points for child restraints are desirable and should be provided in each rear seating position in new Australian cars.

10. Amplification of Australian Design Rule No. 3, "Seat Anchorages for Motor Vehicles" is desirable. The object of such amplification would be to ensure that cushions are retained at the decelerations which the seat structure is required to withstand. The separation of either backrest or seat cushion could have grave consequences for the occupant of a child seat or harness.

PART IV

APPENDICES - INDIVIDUAL PRODUCT APPRAISALS

INDEX OF PRODUCT APPRAISALS

APPENDIX No. 1

MICKLEM 694 CHILD SEAT

Photograph

TARU Negative 328-02

Description

Framed seat with rear protrusion for location under seat back and with hinges to allow folding for storage. It had no crotch strap.

Connection to Car.

By adult lap/sash belts or by adult belt and parcel shelf strap.

Approved Range

9 - 18 kg

APPRAISAL OF CHILD RESTRAINT

Type

Micklem 694 child seat.

Comment

The 694 could be attached to the car with a lap/sash belt or with a lap belt and parcel shelf anchorage, and so could be installed in the centre rear or any side location in many cars. It had a protrusion which slipped between the backrest and cushion in larger cars but which prevented satisfactory installation in some small cars. The seat folded for storage. A lap/sash belt would have provided for restraint of the car seat so, with this form of installation, fitment on tip-up seats such as may be found in station wagons, should be practicable. We have not tested this arrangement.

Adjustment of anchor straps depended upon the type and accessibility of the buckles and adjusters in the seat belt. Current tendencies to reduce the number of adjusters in seat belts may reduce the usefulness of this child seat. The effectiveness of retractors in controlling such child seats under normal braking conditions is not known.

Adjustment of the restraint was found to be easy with all adjusters readily accessible. To remove the occupant none of the adjusters had to be moved. Removal of the occupant was done by unclipping both side restraint clips and lifting the whole restraint over the occupant's head. All adjustments could be made from in front of the seat.

Since this restraint relied upon an adult seat belt for its attachment to the car, it was exposed to the hazard of buckle opening or adjuster slipping if they were allowed to rest against the seat frame. Buckles and adjusters of the seat belt were jammed to prevent such failure in the tests.

The seat located the child further forward in the vehicle than did many other restraints, and used a single strap to anchor the upper part of the seat to the parcel shelf. These features demanded more survival space for the occupant of this restraint than was required by most other restraints. Sufficient space was measured to be available, nevertheless, for our dummy occupant of the child seat to escape head or torso impact had the seat been mounted in the central position of the Falcon and provided that intrusion did not diminish the available space. When mounted in a side position, head and torso were unprotected from impacts with that side.

High speed cinematographs of the child harness indicated satisfactory positioning of the lap strap in spite of its connection to the shoulder straps and the lack of a crotch strap. Shoulder straps tended to fall off before and during the corner and side collisions, and allowed lower shoulder webbing loads but greater head and upper torso excursions.

A wearing trial, utilising a dummy representing a six month old child, indicated that the lateral spacing of the shoulder straps might be excessive. The straps contacted the acromion (outer most point of the shoulder joint) and only the outer edges of the thoracic cage. The shoulder strap anchorages were mounted at head height in this case and could not be relocated. Thus the shoulder straps presented direct obstacles to sideways head motion. These observations were not applicable in the case of the Sierra "Toddler".

Some slip was recorded in adjusters during the tests. The largest measured slip was 57 mm in the adjuster on the left shoulder strap during test number 73032. No damage to the restraint was reported after any of the tests.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Micklem 694 child seat attached by an adult lap/sash belt with the buckle to the left side of the passenger.

Test

Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73084*	73086	73047	73048	73031	73032
New Sample?	No	No	Yes	No	No	No
Sled Deceleration						
Change of Velocity (km/h)	39.1	37.6	37.8	38.6	38.8	38.9
Peak Deceleration (m/s^2)	182	169	164	171	172	170
Duration (ms above 10% of Peak)	100	98	99	97	96	97
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.1	1.5	0.7	1.0	0.3	0.7
L.H. Shoulder	1.4	0.9	1.4	1.2	1.8	0.8
R.H. Lap	1.6	2.3	1.9	2.3	2.4	1.6
L.H. Lap	1.5	1.8	1.3	1.9	0.9	0.7
Crotch	None fitted					

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.46	0.65	0.76	0.90
Shoulders	0.31	0.50	0.62	0.67
Pelvis	0.37	0.52	0.51	0.56
Hands	0.66	0.85	1.00	0.88
Feet	0.96	1.03	1.08	1.16

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	Unsuitable	Unsuitable
Volkswagen 1600 Superbug	Unsuitable	Unsuitable
Ford Falcon	0.65	1.25

* Sled deceleration and webbing tensions were obtained from a re-run, after failure of instrumentation during test 73084.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Micklem 694 child seat attached by an adult lap/sash belt with the buckle to the right side of the passenger.

Test				
Collision Aspect	L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack
Test Number	73057	73058	73033	73034
New Sample?	No	No	No	No
Sled Deceleration				
Change of Velocity (km/h)	37.9	37.9	38.4	38.8
Peak Deceleration (m/s^2)	167	167	170	169
Duration (ms above 10% of Peak)	99	98	97	97
Peak Webbing Tensions (kN)				
R.H. Shoulder	0.7	0.8	0.3	0.7
L.H. Shoulder	1.6	2.0	1.6	1.0
R.H. Lap	1.7	2.2	1.6	1.6
L.H. Lap	1.2	1.4	0.9	0.7
Crotch	None fitted			
Space Requirements (m)			Sideways Space	
Head			0.75	0.93
Shoulders			0.63	0.72
Pelvis			0.49	0.59
Hands			0.95	0.91
Feet			1.09	1.04
Space Availability (m)				
Morris Mini De-Luxe			Unsuitable	
Volkswagen 1600 Superbug			Unsuitable	
Ford Falcon			0.35	

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Micklem 694 child seat attached by an adult lap belt and a parcel shelf strap

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73087	73088	73059	73060	73035	73036
New Sample?	No	No	No	No	No	No
Sled Deceleration						
Change of Velocity (km/h)	39.0	38.0	38.6	38.1	38.9	39.3
Peak Deceleration (m/s^2)	170	168	169	167	172	173
Duration (ms above 10% of Peak)	100	100	99	98	97	98
Peak Webbing Tensions (kN)						
R.H. Shoulder	0.7	1.2	0.5	0.8	0.2	0.6
L.H. Shoulder	1.2	1.5	1.4	1.7	1.8	1.6
R.H. Lap	0.9	1.5	1.2	1.6	1.3	1.4
L.H. Lap	1.0	1.5	0.8	0.9	0.7	0.7
Crotch	None fitted					

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.43	0.61	0.62	0.78
Shoulders	0.26	0.44	0.55	0.64
Pelvis	0.36	0.50	0.50	0.58
Hands	0.61	0.80	0.82	0.88
Feet	0.94	1.02	1.07	1.25

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	Unsuitable	Unsuitable
Volkswagen 1600 Superbug	Unsuitable	Unsuitable
Ford Falcon	0.65	0.80

APPENDIX No. 2

STEELCRAFT C54 CHILD SEAT

Photograph

TARU Negative 328-06

Description

Rigid framed seat without crotch strap.

Connection to Car

By adult lap belt and parcel shelf strap.

Approved Range

1 - 4 years, 9 - 18 kg.

Similar Approved Restraints

Cyclops C54

Stork C54

APPRAISAL OF CHILD RESTRAINT

Type

Steelcraft C54 child seat.

Comment

The C54 required a parcel shelf or equivalent structure and so could not conveniently be connected in front seats or in station waggons. (A top anchorage on the wheel arch appeared a possibility for rear seats in station waggons). It was not known whether the parcel shelf strap would be strong enough to restrain the car seat squab in the event of a crash.

Adjustment of the restraint was found to be quite easy, with all adjustments accessible. Once adjusted, the restraint remained in adjustment, even after removal and replacement of the occupant. Removal and placement of the occupant was effected by slipping the lap belt out through the loops on the shoulder harness and lifting the harness over the occupant's head. All adjustments could be made from the front.

In the Mini, the available space for the occupant of the Steelcraft C54 child seat was estimated with the seat located in the left seating position to avoid the ridge which runs down the centre of the seat back. In the two other cars, estimates were based upon central location of the child seat in the rear seat.

Since this restraint relied upon an adult lap belt for its attachment to the car, it was exposed to the hazard of buckle opening or adjuster slipping if they were allowed to rest against the seat frame. Buckles and adjusters of the seat belt were jammed to prevent such failure in the tests.

The occupant was located away from the rear seat by this child seat, which was attached to the parcel shelf by only one strap. These features appeared to need more survival space in the car and also appeared to contribute a risk of impact of the head and torso of the occupant against the back of the front seats in the Volkswagen, and against the side of both the Volkswagen and Mini.

High speed cinematographs indicated a risk of internal injury from the lap strap of the harness. The lap section of the harness was pulled up high by the shoulder straps, and the seat pan deformed downwards to allow the dummy to slide under the lap strap until the strap rested across its chest.

A wearing trial, utilising a dummy which represented a six month old child, indicated that lateral spacing of the shoulder straps could be excessive. The straps contacted this dummy only at the acromion (outermost point of the shoulder joint) and on the lateral extremes of the thoracic cage. In addition, the vertical location of the shoulder strap securing points was fixed at head height. Thus the straps presented a direct obstacle to sideways movement of the head.

Some slip was recorded in adjusters during the test series. The largest measured slip was 19 mm in the lap strap during test number 73089. The bar connecting parcel shelf strap, shoulder straps, and seat frame was noted to have been permanently bent by most of the tests.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Steelcraft C54 child seat connected with an adult lap belt and a parcel shelf strap.

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73089	73096	73061	73062	73037	73038
New Sample?	Yes	Yes	Yes	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	38.6	38.7	37.2	38.0	39.1	39.7
Peak Deceleration (m/s^2)	170	172	161	167	174	176
Duration (ms above 10% of Peak)	100	100	99	98	96	97
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.1	1.3	0.6	0.5	0.5	0.3
L.H. Shoulder	1.5	1.6	1.1	1.5	1.9	2.0
R.H. Lap	1.1	1.3	1.1	1.6	1.6	1.8
L.H. Lap	1.0	1.1	0.8	1.2	0.6	0.9
Crotch	None fitted					

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.41	0.54	0.60	0.69
Shoulders	0.29	0.40	0.53	0.68
Pelvis	0.37	0.50	0.44	0.55
Hands	0.63	0.78	0.83	1.01
Feet	0.93	1.04	1.09	1.25

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	0.59	0.34
Volkswagen 1600 Superbug	0.46	0.59
Ford Falcon	0.58	0.80

APPENDIX No. 3

STEELCRAFT C57 CHILD SEAT

Photograph

TARU Negative 443-05

Description

Bucket seat with detachable crotch strap.

Connection to Car

One parcel shelf and two floor anchorages had to be fitted.

Approved Range

9 to 18 kg.

APPRAISAL OF CHILD RESTRAINT

Type

Steelcraft C57 child seat.

Comment

The Steelcraft C57 had a moderately long parcel shelf attachment strap and could possibly have been installed in some station waggons as well as sedans. We cannot recommend such fitment however since it is not known whether the anchor strap would have adequately restrained the child seat in side impact.

The shoulder straps of the restraint were found to be particularly difficult to adjust, indeed their adjustment was almost impossible once the seat had been anchored in position. The lap strap was quite easy to adjust by comparison. Removal and replacement of the child was facilitated by the possibility of separation of lap belt, crotch strap and shoulder harness.

A trial fitment of a dummy, representing a six month old child, indicated that lateral separation of the shoulder straps appeared to be excessive. The straps were found to contact only the acromion (the outermost point of the shoulder joint) and the lateral extremities of the thoracic cage. This effect was not observed with the Sierra "Toddler" in the seat.

Our estimates of available space were based upon installation of the child seat in the centre of the rear seat of each of the three cars. Central installation in the Mini necessitated tight adjustment of the anchorage straps to avoid rocking of the seat on the ridge which ran up the middle of the rear seat.

Analysis of cinematographs indicated that acceptable clearance existed between the dummy's head and torso, and the interior surfaces of undamaged vehicles in all frontal crash simulations other than 74-003. In this case, with the crotch strap disconnected and harness slack, there was a possibility of impact of the lower torso in the Volkswagen. In side impact simulations also there appeared to be insufficient space in the Volkswagen, even with crotch strap connected and harness tight.

Alternative tests with the crotch strap connected and disconnected indicated higher shoulder harness forces in the former case. This could be accounted for by submarining which was observed when the crotch strap was omitted.

No slip was noted in the adjusters during the tests. In one case on run 73-221 the right hand lap belt adjuster siezed tightly on the webbing and could not be freed.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Steelcraft C57 child seat with crotch strap connected

Test						
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73.223	73.224	73.220	73.219	73.221	73.222
New Sample?	Yes	No	No	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	39.5	39.8	39.5	40.0	39.1	39.7
Peak Deceleration (m/s^2)	171.5	175.3	172.0	177.0	181.6	179.0
Duration (ms above 10% of Peak)	101	101	100	99	93	95
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.29	1.19	.98	.61	.63	.45
L.H. Shoulder	1.26	1.50	1.25	1.51	1.45	1.39
R.H. Lap	1.62	1.45	1.33	1.63	1.62	1.53
L.H. Lap	2.06	1.77	1.00	1.15	.90	.92
Crotch	.69	.91	.74	.91	.89	.91
Space Requirements (m)	Forwards Space				Sideways Space	
Head	.40	.45	.90	.20	.29	.40
Shoulders	.17	.21	.17	.24	.21	.34
Pelvis	.29	.32	.07	.19	.17	.32
Hands	.62	.60	.33	.46	.54	.65
Feet	.94	.83	.44	.51	.64	.73

Space Availability (m)

	Forwards	Sideways
Morris Mini De-Luxe	.63	.57
Volkswagen 1600 Superbug	.49	.29
Ford Falcon	.66	.80

APPENDIX No. 4

BRITAX B335 CHILD SEAT

Photograph

TARU Negative 400-20

Description

Bucket seat with optional crotch strap.

Connection to Car

Two parcel and one floor anchorages to be fitted.

Approved Range

1 - 4½ years, 9 - 18 kg.

APPRAISAL OF CHILD RESTRAINT

Type

Britax B335 child seat.

Comment

The B335 required a parcel shelf or equivalent structure, and so could not easily be installed in front seats or in station waggons. (A top anchorage on the wheel arch appeared a possibility for rear seats of station waggons.) It was not known whether the child seat anchor straps would be strong enough to restrain the car seat squab in the event of a crash.

Adjustment of the restraint was found to be difficult, because of the design and positioning of the adjusters. Removal and placement of the occupant in the restraint was found to be very difficult because of the shoulder straps which needed to be re-adjusted when the occupant was replaced. To pull the restraint up tightly was found to be a two man job, one pushing the restraint into the seat and one taking up the slack on the floor strap adjuster. We had to undo the seat from the parcel shelf anchorages in order to adjust the shoulder straps.

Estimates of available space were made for the Britax B335 child seat with it mounted in the left position of the Mini rear seat and in the centre of the Volkswagen and Ford rear seat.

Cinematographs indicated acceptable clearance between the head and torso of the dummy occupant and the interior of undamaged vehicles, had the seat been mounted in the centre of the rear seat.

The crotch strap was attached to the buckle of this restraint by a formed metal plate which broke during tests 73130 and 73131 and which bent during other tests. Limited submarining of the dummy resulted as the crotch strap detached or lengthened. The bent plate appeared capable of inflicting injury on the passenger.

A long tear occurred in the seat shell during test 73119. It ran diagonally upwards from the slot of the right lap strap.

The side of the seat appeared to restrain the passenger during side collision.

A wearing trial was conducted, using a dummy which represented a six month old child. Lateral spacing of the shoulder straps appeared to be excessive and it was noted that the spacing between the straps was identical in each of the alternative upper and lower anchorage positions. The shoulder straps contacted the dummy's torso at the acromion (outermost point of the shoulder joint) and on the lateral extremities of the thoracic cage.

These observations were not evident when the larger Sierra "Toddler" dummy occupied the seat.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Britax B335 child seat.**

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73130	73131	73155	73156	73119	73120
New Sample?	Yes	Yes	Yes	Yes	Yes	Yes
Sled Deceleration						
Change of Velocity (km/h)	40.3	40.3	38.4	37.7	40.7	38.5
Peak Deceleration (m/s^2)	176	180	165	163	183	169
Duration (ms above 10% of Peak)	99	99	99	99	97	98
Peak Webbing Tensions (kN)						
R.H. Shoulder	0.9	0.8	1.0	1.2	1.3	1.0
L.H. Shoulder	1.3	1.5	0.7	0.6	0.5	0.3
R.H. Lap	0.7	0.5	0.6	0.7	0.4	0.5
L.H. Lap	1.1	0.5	0.6	1.0	0.6	0.5
Crotch	1.4	1.6	0.9	0.8	0.5	0.6

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.31	0.42	0.46	0.53
Shoulders	0.17	0.21	0.43	0.49
Pelvis	0.37	0.37	0.26	0.42
Hands	0.54	0.60	0.72	0.77
Feet	0.89	0.95	0.97	1.09

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	0.57	0.31
Volkswagen 1600 Superbug	0.57	0.59
Ford Falcon	0.63	0.80

APPENDIX No. 5

SAFE-N-SOUND PREMIER MODEL X4 CHILD SEAT

Photograph

TARU Negative 400-19

Description

Bucket seat with crotch strap which had to be used; all other straps attaching to it.

Connection to Car

Two parcel anchorages and one floor anchorage to be fitted.

Approved Range

9 - 18 kg.

APPRAISAL OF CHILD RESTRAINT

Type

Safe-N-Sound X4 child seat.

Comment

This child seat was intended for installation in the rear seat of sedans.

With its long parcel shelf straps, it was possible to fit it in the rear of station waggons by attachment of the top straps to the wheel arch. It was,however,not known whether the child seat anchor straps would be strong enough to restrain the car seat squab in the event of a crash. We considered the child seat to be unsuitable for fitting in front seats.

We found this restraint very difficult to adjust because of the design and positioning of the adjusters. Removal and placement of the occupant was quite easily achieved by unclipping the shoulder straps, and could be done without changing the adjustment. We could not adjust the straps from the front and found it to be a two man job to adjust the floor strap.

A ridge running down the back makes the centre of the rear seat of the Mini a difficult location for installation of the Safe-N-Sound X4 child seat. Available space was therefore estimated with the child seat mounted in the left seating position. The central rear seating position was used for the estimations in the Volkswagen and Ford.

Cinematographs indicated satisfactory clearance between the dummy's head and torso and the interior of undamaged cars had the restraint been mounted in the centre of the rear seat. Loose adjustment resulted in some limited submarining under the lap straps.

Various parts of the restraint suffered damage during the test program. The plastic lever of the buckle stalk broke off and allowed the shoulder straps to detach during test 73129. Shoulder and head had already been sufficiently decelerated when this occurred, however, and jackknifing did not result. Webbing tore in the vicinity of eyelets during most tests, but the eyelets did not separate completely from the webbing. Damage to the plastic seat shell was reported after four tests on the same seat, with fractures up to 225 mm long leading from slots through which the webbing passed. The worst damage occurred to the slots carrying the lap straps and this failure resulted in much of the restraining being done by the crotch and shoulder straps. This damage did not occur when a device was subjected to but one crash.

The largest measure of adjuster slip was 10 mm at the right parcel shelf anchorage during test 73154.

A wearing trial, utilising a dummy representative of a six month old child, indicated that the harness was well suited to the very small occupant. Harness geometry was in the form of a diagonal cross with the buckle at the centre. When the lap belt was adjusted to lie as closely as possible to the pelvis, the 'vee' pattern of the shoulder straps ensured that these lay flat on the central area of the thoracic cage. However, the shoulder straps were spaced similarly in the lower pair of anchoring slots as in the upper pair and the shoulder harness could have been improved for the smaller child by a reduction in this lateral spacing.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Safe-N-Sound X4 child seat.**

Test

	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73129	73132	73161	73154	73117	73118
New Sample?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Sled Deceleration						
Change of Velocity (km/h)	36.0	40.2	39.6	39.3	36.7	36.0
Peak Deceleration (m/s^2)	152	183	172	171	162	156
Duration (ms above 10% of Peak)	101	98	99	98	98	98
Peak Webbing Tensions (kN)						
R.H. Shoulder	0.6	0.9	1.2	0.9	1.1	0.7
L.H. Shoulder	0.8	0.8	1.0	0.5	0.5	0.2
R.H. Lap	0.7	0.5	0.7	0.6	0.3	0.4
L.H. Lap	0.6	1.0	0.8	0.4	0.4	0.4
Crotch	?	1.2	0.8	0.8	0.5	0.6

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.40	0.46	0.41	0.59
Shoulders	0.16	0.33	0.33	0.48
Pelvis	0.25	0.35	0.25	0.46
Hands	0.58	0.66	0.53	0.67
Feet	0.82	0.96	0.67	0.83

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	0.58	0.32
Volkswagen 1600 Superbug	0.56	0.59
Ford Falcon	0.63	0.80

APPENDIX No. 6

SAFE-N-SOUND KL CHILD SEAT

Photograph

TARU Negative 328-14

Description

Bucket seat with optional crotch strap.

Connection to Car

Two parcel and two floor anchorages to be fitted.

Approved Range

9 - 18 kg.

Similar Approved Restraint

Safe-N-Sound Motorcraft child seat.

APPRAISAL OF CHILD RESTRAINT

Type

Safe-N-Sound KL child seat.

Comment

This device was intended for installation in the rear of sedans.

With its long parcel shelf straps, it was possible to fit it in the rear of station waggons by attachment of the top straps to the wheel arches. It was not known, however, whether the child seat anchor straps would be strong enough to restrain the car seat squab in the event of a crash. We believed the child seat to be unsuitable for front seats.

We found this restraint to be the most difficult of all of the approved restraints to adjust. We were unable to adjust the restraint straps for the occupant when the seat was anchored in position. We also found removal and placement of the occupant to be difficult because the shoulder straps were attached to the lap straps. Loosening of the anchor straps was found to be a necessary and difficult pre-requisite to removal of the child restraint.

The estimates of available space were based upon installation of the Safe-N-Sound KL seat in the centre of the rear seat of each of the three cars. Central installation in the Mini required tight adjustment of the installation straps to avoid rocking by the seat on the ridge which ran up the middle of the rear seat.

The seat located the occupant further back in the vehicle passenger compartment than did some bulkier seats, and was the only approved restraint with four attachments to the car. These features demanded less space for the occupant. With tight adjustment, measurements of cinematographs indicated sufficient clearance in each of the three cars to prevent impact to the dummy occupant's head or torso from the back of front seats and from the car sides, provided there was no intrusion. Our measurements indicated that very loose adjustment in the two smaller cars could have allowed the head to impact the back of the front seat, and both the head and torso to impact the car side.

Tests with the crotch strap connected and disconnected gave similar results. High speed cinematography indicated some submarining in both cases when the restraint was adjusted very loosely.

Trial fitment of a dummy, representative of a six month old child, indicated that lateral separation of the shoulder straps could be excessive, even when they were anchored in the lower of the two positions available. The straps contacted the dummy's torso on the acromion (outermost point of the shoulder joint) and on the lateral extremities of the thoracic cage. This effect was not observed when the larger Sierra "Toddler" dummy was placed in the seat.

The sides of the bucket seat, whilst apparently useful in limiting the sideways movement of a tightly restrained child, appeared ineffective when the adjusters were all left very loose. In test number 73158 the occupant rode past the side of the seat and his head rebounded onto its sharp edge.

Some slip was recorded at adjusters after some of the tests. The largest slip noted was 48 mm at the lower right anchor plate during test 73051. Buckling of anchor plates, and slight cutting of webbing, were noted for the lower installation plates after test 73126.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Safe-N-Sound KL child seat with crotch strap connected.

	Head-on		L. Front Cnr		Left Side	
Test						
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73090	73091	73049	73051	73039	73040
New Sample?	Yes	No	Yes	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	39.0	38.5	38.6	38.2	39.2	39.5
Peak Deceleration (m/s^2)	171	170	170	167	176	174
Duration (ms above 10% of Peak)	100	99	98	97	95	97
Peak Webbing Tensions (kN)						
R.H. Shoulder	0.9	0.9	0.7	1.2	0.6	0.2
L.H. Shoulder	1.2	1.7	1.3	1.6	1.3	1.3
R.H. Lap	1.2	1.7	1.1	1.1	1.3	1.2
L.H. Lap	1.2	1.7	0.9	1.1	0.7	0.6
Crotch	0.3	0.2	0.5	1.1	0.	0.

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.38	0.61	0.55	0.70
Shoulders	0.22	0.42	0.46	0.61
Pelvis	0.28	0.44	0.34	0.51
Hands	0.60	0.71	0.76	0.98
Feet	0.73	0.96	0.89	1.10

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	0.63	0.57
Volkswagen 1600 Superbug	0.50	0.59
Ford Falcon	0.66	0.80

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Safe-N-Sound KL child seat with crotch strap disconnected.

Test

	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73135	73136	73157	73158	73125	73126
New Sample?	Yes	No	No	No	No	No
Sled Deceleration						
Change of Velocity (km/h)	38.6	37.8	39.0	38.7	37.6	38.0
Peak Deceleration (m/s^2)	166	164	168	166	167	166
Duration (ms above 10% of Peak)	100	100	100	99	99	98
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.0	0.7	0.6	0.5	0.3	0.2
L.H. Shoulder	1.1	1.0	0.7	1.0	0.5	1.2
R.H. Lap	1.5	1.6	1.4	1.6	1.3	1.5
L.H. Lap	1.4	1.9	0.9	1.5	0.8	0.8
Crotch						

Space Requirements (m)

	Forwards Space		Sideways Space	
Head	0.36	0.55	0.46	0.54
Shoulders	0.17	0.37	0.45	0.61
Pelvis	0.22	0.43	0.22	0.38
Hands	0.50	0.69	0.71	0.88
Feet	0.83	0.98	0.86	1.02

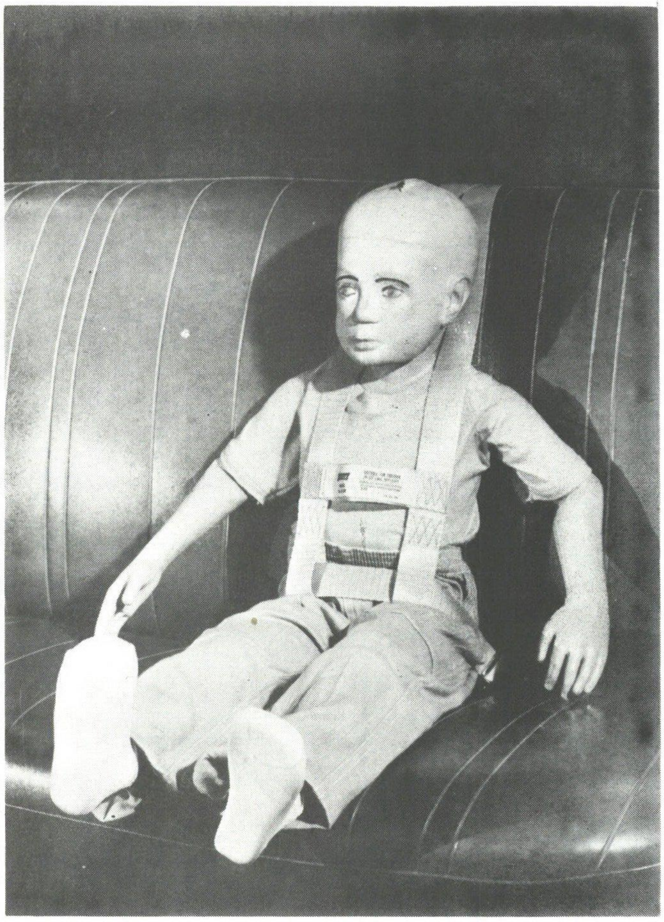
Space Availability (m)

	Forwards	Sideways
Morris Mini De-Luxe	0.63	0.57
Volkswagen 1600 Superbug	0.50	0.59
Ford Falcon	0.66	0.80

APPENDIX No. 7

BRITAX B336 HARNESS

Photograph



TARU Negative 328-08

Description

Shoulder harness and light weight lap belt.

Connection to Car

Lap belt replaced adult lap belt. Parcel anchorage to be fitted.

Approved Range

2½ - 11½ years, 9 - 36 kg.

APPRAISAL OF CHILD RESTRAINT

Type

Britax B336 child harness.

Comment

We were unable to install the B336 in the Mini without leaving excessive slack in the shoulder straps. The restraint could have been installed conveniently in the centre of the rear of larger sedans; without the provision of a long shoulder attachment (not necessarily recommended), we found it to be unsuitable for rear seats of station waggons and for front seats generally. This harness did not provide for restraint of the car seat in the event of a crash and could only be used where the car seat was constructed to sustain crash forces (as is claimed by the manufacturers of some post-1967 cars).

Adjustment was found to be easy with both adjusters readily accessible. Placement and removal of the occupant was accomplished by either of two methods; by slipping the lap belt completely out of the loops of the shoulder straps and lifting them over the occupant's head, or by undoing the lap belt and slipping the occupant out sideways. Both adjustments could be made from in front of the restraint. Release under load might be difficult but should only arise in an upturned vehicle.

The Britax B336 was only satisfactorily installed by us in the Volkswagen and Ford. Its space requirements were estimated for mountings in the centre of the rear seat of these vehicles.

Measurements of cinematographs indicated good forward clearance between the occupant's head and torso and the back of the front seats had it been mounted inside undamaged cars. When adjusted loosely, the head and shoulders appeared likely to impact the side had the restraint been used in the Volkswagen.

A better view is sometimes provided for the occupant of a harness by raising him on a cushion. When tested with the dummy mounted on a thin cushion, submarining appeared to be increased. When the restraint was used with the occupant sitting on a firm but heavy pouffe the pouffe ejected and serious submarining resulted with the lap strap finishing across the upper chest, and the chest strap resting on the dummy's neck.

40 mm of slip was noted to have occurred at the buckle during 73042.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Britax B336 child harness.**

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73092	73093	73054	73053	73041	73042
New Sample?	Yes	No	No	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	38.9	38.9	38.5	38.8	39.7	40.0
Peak Deceleration (m/s^2)	172	173	168	172	177	174
Duration (ms above 10% of Peak)	100	100	99	98	97	97
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.3	1.4	0.6	0.6	0.1	0.2
L.H. Shoulder	1.8	1.5	1.8	1.7	1.8	1.3
R.H. Lap	1.8	1.9	2.1	2.4	2.4	1.9
L.H. Lap	2.0	1.8	1.1	1.3	0.9	1.8
Crotch						

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.39	0.48	0.55	0.69
Shoulders	0.23	0.31	0.48	0.60
Pelvis	0.29	0.34	0.36	0.57
Hands	0.61	0.70	0.78	0.95
Feet	0.85	0.91	0.96	1.05

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	Unsuitable	Unsuitable
Volkswagen 1600 Superbug	0.54	0.59
Ford Falcon	0.66	0.80

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

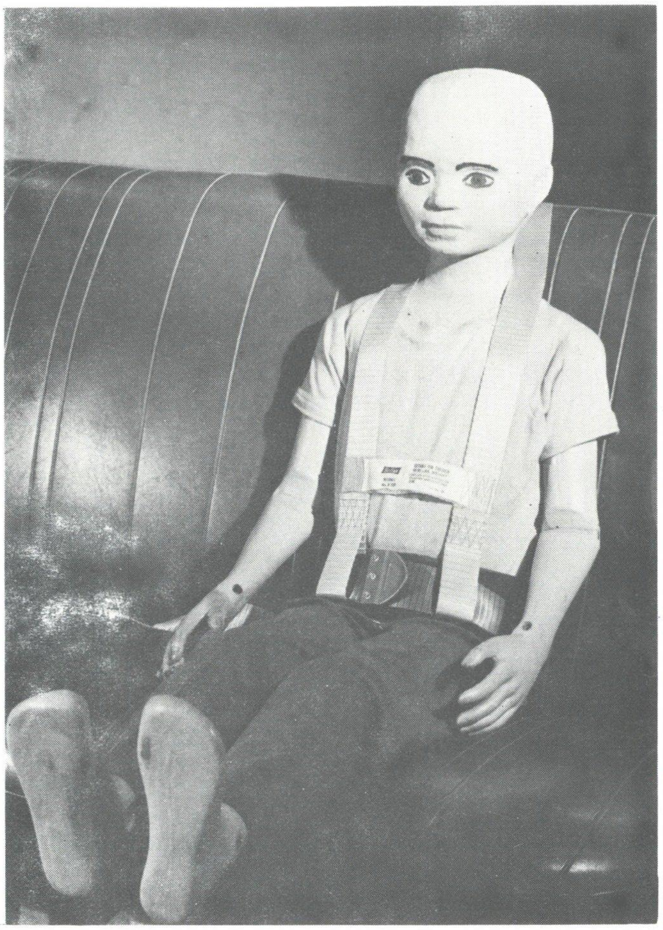
Restraint Type:- **Britax B336 child harness with cushion.**

Test	Thin cushion		Pouf	
Collision Aspect	Head-on		Head-on	
Tight or Slack	Tight	Slack	Tight	Slack
Test Number	73104	73105	73106	73107
New Sample?	No	No	No	No
Sled Deceleration				
Change of Velocity (km/h)	39.0	39.0	39.2	39.2
Peak Deceleration (m/s^2)	170	175	174	176
Duration (ms above 10% of Peak)	100	100	100	99
Peak Webbing Tensions (kN)				
R.H. Shoulder	1.1	1.2	1.8	1.9
L.H. Shoulder	1.3	1.5	1.6	1.5
R.H. Lap	1.5	1.8	1.4	1.5
L.H. Lap	1.6	2.3	1.3	1.4
Crotch				
Space Requirements (m)	Forwards Space			
Head	0.39	0.48		
Shoulders	0.24	0.36		
Pelvis	0.31	0.38		
Hands	0.62	0.64		
Feet	0.88	0.90		
Space Availability (m)				
Morris Mini De-Luxe	Unsuitable			
Volkswagen 1600 Superbug	0.54			
Ford Falcon	0.66			

APPENDIX No. 8

BRITAX B338 HARNESS

Photograph



TARU Negative 328-12

Description

Shoulder harness which looped onto an adult lap belt.

Connection to Car

Adult lap belt to be available. Parcel anchorage to be fitted.

Approved Range

5 - 11½ years, 18 - 36 kg.

APPRAISAL OF CHILD RESTRAINT

Type

Britax B338 child harness.

Comment.

We were unable to install the B338 in the Mini without leaving excessive slack in the shoulder straps. The restraint could be installed conveniently in the centre of the rear of larger sedans; however we believe that, without longer shoulder straps (not necessarily recommended) it was unsuitable for rear seats of station waggons and for front seats generally. This harness did not provide for restraint of the car seat in the event of a crash and could only be used where the car seat was constructed to sustain crash forces (as claimed by the manufacturers of some post-1967 cars).

Adjustment was found to be easy with both adjusters readily accessible. Placement and removal of the occupant was accomplished by either of two methods; by slipping the lap belt completely out of the loops of the shoulder straps and lifting them over the occupant's head, or by undoing the lap belt and slipping the occupant out sideways. Both adjustments could be made from in front of the restraint. Release under load might be difficult but should only arise in an upturned vehicle.

The Britax B338 was only satisfactorily installed by us in the Volkswagen and Ford. Its space requirements were estimated for mountings in the centre of the rear seat of these vehicles.

Since the harness was approved for larger children, our tests were carried out with a larger dummy, representing a 6 year old child.

Cinematographs indicated good forward clearance for the head and torso of the dummy had it been riding in undamaged vehicles. Head and shoulders suffered large sideways excursions, however, and appeared likely to impact the side of the Volkswagen and Ford. These excursions were partly caused by tearing of the shoulder strap. The straps were severed by a guide plate on the parcel shelf, in the side impacts of 73043 and 73044, and partial cutting was noted after 73056.

Good location of the lap strap was noted, but may have been assisted by the rather generous pelvis of the dummy. The use of a cushion under the passenger of this restraint could be a temptation to drivers wishing to provide their child passenger a better view. Tests on the Britax B336 indicated that this might be hazardous.

The largest slip noted for the adjuster of the restraint was 7 mm at the parcel shelf during test 73095.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Britax B338 child harness and adult lap belt.**

Test

	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73094	73095	73055	73056	73043	73044
New Sample?	Yes	No	Yes	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	38.7	38.1	37.5	37.7	38.3	37.8
Peak Deceleration (m/s^2)	169	172	162	167	171	169
Duration (ms above 10% of Peak)	102	101	100	100	97	96
Peak Webbing Tensions (kN)						
R.H. Shoulder	2.4	2.6	1.4	1.5	0.5	0.4
L.H. Shoulder	2.6	2.7	2.7	3.4	1.2	1.2
R.H. Lap	3.7	4.4	Not measured			
L.H. Lap						
Crotch						

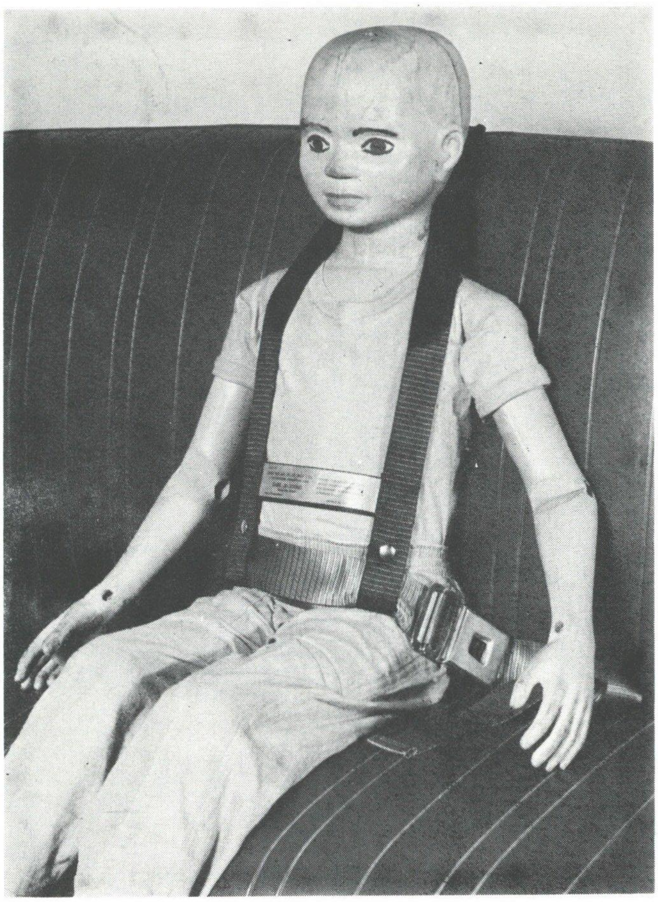
Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.40	0.49	0.76	0.79
Shoulders	0.30	0.35	0.58	0.60
Pelvis	0.36	0.42	0.44	0.39
Hands	0.74	0.79	1.03	1.06
Feet	0.92	0.97	0.97	0.98

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	Unsuitable	Unsuitable
Volkswagen 1600 Superbug	0.54	0.59
Ford Falcon	0.66	0.80

APPENDIX No. 9

SAFE-N-SOUND SS150 HARNESS

Photograph



TARU Negative 400-11

Description

Shoulder harness which looped onto an adult lap belt.

Connection to Car

Adult lap belt to be available. Parcel anchorage to be fitted.

Approved Range

4½ - 11½ years, 18 - 36 kg.

Similar Approved Restraint

Safe-N-Sound SS155 Harness.

APPRAISAL OF CHILD RESTRAINT

Type

Safe-N-Sound SS150 child harness.

Comment

We were unable to install the SS150 in the Mini without leaving excessive slack in the shoulder straps. The restraint could be installed conveniently in the centre of the rear of larger sedans; however we believe that, without longer straps (not necessarily recommended), it was unsuitable for rear seats of station waggons and for front seats generally and for seats in which lap/sash belts are fitted. This harness did not provide for restraint of the car seat in the event of a crash and could only be used where the car seat was constructed to sustain crash forces (as claimed by the manufacturers of some post-1967 cars).

Adjustment was found to be easy with both adjusters readily accessible. Placement and removal of the occupant was accomplished by either of two methods; by slipping the lap belt completely out of the loops of the shoulder straps and lifting them over the occupant's head, or by undoing the lap belt and slipping the occupant out sideways. Both adjustments could be made from in front of the restraint. Release under load might be difficult but should only arise in an upturned vehicle.

The space requirements of the Safe-N-Sound SS150 child harness were examined with it mounted in the left hand rear seat of the Mini and in the centre of the rear seat of the Volkswagen and Ford.

The harness was approved for use with larger children than are most child restraints and was tested with a larger 6 year old dummy.

Analysis of cinematographs indicated good forwards clearance for the dummy's head and torso.

The lap strap was generally well located although we considered that the larger dummy's prominent pelvis was unduly helpful in this regard. The lap strap tended to "rope" during collision.

A child wearing this restraint might well complain of the lack of a view. The effects of a cushion were not tested, but tests on a similar restraint have indicated a risk of submarining by a passenger seated either on a substantial but unrestrained cushion or on a restrained but light and easily compressed cushion.

The largest recorded slip of an adjuster was 8 mm at the parcel shelf anchorage in test 73159.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Safe-N-Sound SS150 child harness.**

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73133	73134	73159	73160	73121	73122
New Sample?	Yes	No	Yes	No	Yes	No
Sled Deceleration						
Change of Velocity (km/h)	37.8	37.6	38.8	38.1	37.0	37.0
Peak Deceleration (m/s^2)	163	166	166	166	162	163
Duration (ms above 10% of Peak)	101	101	100	100	99	98
Peak Webbing Tensions (kN)						
R.H. Shoulder	1.7	1.7	1.0	1.1	0.7	0.8
L.H. Shoulder	1.8	2.1	1.9	2.0	1.4	1.3
R.H. Lap						
L.H. Lap						
Crotch						

Space Requirements (m)	Forewards Space		Sideways Space	
Head	0.44	0.52	0.57	0.70
Shoulders	0.23	0.34	0.48	0.55
Pelvis	0.29	0.31	0.21	0.28
Hands	0.71	0.78	0.90	1.02
Feet	1.00	1.08	0.97	0.98

Space Availability (m)	Forewards	Sideways
Morris Mini De-Luxe	0.65	0.26
Volkswagen 1600 Superbug	0.63	0.57
Ford Falcon	0.71	0.75

APPENDIX No. 10

VOLVO CHILD RESTRAINT SEAT

Photograph

TARU Negative 419-02

Description

A rearward facing bucket seat with integral harness, specifically designed for Volvo cars.

The seat was not SAA-approved

Connection to Car.

Secured to anchorages at glove box and leading edge of front passenger seat frame. Installation necessitated removal of front seat cushion.

Specified Age Range

Children up to 6 years.

APPRAISAL OF CHILD SEAT

Type

Volvo.

Comment

This rear facing seat was specially designed for installation in the front passenger's seating position of Volvo cars and was not readily adaptable to other vehicles. Installation could be effected without the use of tools; the top of the seat rested against the dashboard and was secured by a strap which hooked on to a bracket under the glove box; the bottom of the seat had a locking bracket which picked up the leading edge of the passenger seat after its cushion had been removed.

The seat appeared not to comply with the requirements of AS E46 in at least the following respects:-

1. The harness webbing was not permanently attached to anchor fittings or the buckle.
2. Padding of restraint enclosure did not comply with SAA requirements for head restraint.

Further to these items, compliance with the Standard would have required it to be shown that the webbing complied with AS E47-1971, and that the assembly could satisfy the requirements of the static loading test specified in AS E46-1970.

Harness adjustment was quite difficult; the adjusters were of a type that required extra webbing to be fed in before they could be either slackened or tightened. Thus we invariably found it necessary to unclasp the buckle prior to adjustment, and this meant that correct fit could only be achieved by trial and error. Because the lap strap was a continuous unanchored loop, its adjustment always necessitated a circumferential displacement to return the buckle to a central location.

The seat shell appeared to have been moulded in a semi-rigid polyurethane foam. It proved to be sufficiently strong to restrain the dummy in both forward and 45^{o} impact without sustaining any observable damage. We are unable to state whether the properties of the shell were such that a satisfactory "ride down" would be provided; an accelerometer in the dummy's chest in the frontal simulation recorded a peak reading of 13.7 g whilst peak sled deceleration was 16.4 g. It is not considered that anthropomorphic dummies are sufficiently representative of live subjects to justify the direct use of their accelerometer readings. The dummy was not instrumented in the 45° simulations.

In frontal impact, dummy excursion, as a result of restraint system deflection, appeared to be less than is normally observed in a forward facing harness system. The magnitude of deceleration forces should be mitigated by their distribution over the entire torso and head of the occupant.

Examination of high speed cinematographs indicated that, in 45° impacts, the dummy's shoulder could slip out of its harness on the further side from the impact point. Dummy excursions were not measured in the 45° case but appeared to be comparable to conventional approved seats. We consider it to be possible that, in left hand side impacts, the occupant of a Volvo child seat installation could contact inside surfaces of the vehicle.

We were unable to wholly endorse the vehicle location recommended for the Volvo child seat. The occupant was located very near to the inside surface of the door and at virtually the furthest forward point possible within the passenger compartment. Clearly a child occupant in such a location must be exposed to a higher risk of injury from even a moderate intrusion or structural deformation than he would be when seated in a forward facing seat, or located in the rear compartment.

SUMMARY OF DYNAMIC TEST RESULTS FOR UNAPPROVED CHILD SEAT

Seat Type

Volvo rear facing child seat.

Test Procedure

The Volvo seat was originally tested in a frontal impact simulation in an early series of tests when it was fitted in the front seat of an adapted Morris Mini car. In the latest series, a 45° side impact was examined, a special test rig being constructed to simulate the Volvo anchorages.

In all simulations the Sierra "Toddler" "3 year old" dummy was used. The harness was adjusted tightly for the one frontal impact whilst tight and slack adjustments were examined in the 45° case.

Webbing forces were not recorded in the frontal impact.

Sled deceleration data and space requirements are presented in the table overleaf.

TABLE OF DYNAMIC TEST RESULTS -- VOLVO CHILD SEAT

CONFIGURATION OF DEVICE	RUN NUMBER	SLED DECELERATION VELOCITY CHANGE km/h	PEAK DECELERATION m/s^2	DURATION *	HARNESS LOADS	OBSERVATIONS
Installed in Morris Mini	PK19	not recorded	161	100	Not measured	Dummy was restrained. Slight flexure in shell.
Special Test Rig 45° impact Harness tight	73-215	40.1	174	98	R.H. Shoulder : .12 L.H. Shoulder : .10 R.H. Lap : .52 L.H. Lap : .27	Seat rolled about top mounting point. Dummy moved in direction of impact relative to seat, shoulder furthest from impact almost out of harness.
Special Test Rig 45° impact Harness slack (75 mm at each adjuster)	73-216	38.7	175	98	R.H. Shoulder : .12 L.H. Shoulder : .71 R.H. Lap : .71 L.H. Lap : .72	Seat rolled about top mounting point. Dummy moved relative to seat. Shoulder furthest from impact point came out of harness; arm nearest impact flailed out from seat; legs swung toward impact.

* Duration is portion of pulse above 10% of peak deceleration.

APPENDIX No. 11

General Motors "Love" Child Restraining Seat.

Photograph

Modified layout GM layout

Description

Forward facing bucket seat with integral harness including crotch strap. Primarily intended for specified General Motors cars and station waggons but could be used in some other vehicles.

The seat was not SAA approved.

Anchorage System

The seat was intended to be secured by an adult's seat belt in conjunction with a strap attached to the top of its moulded plastic shell.

For rear seat installations the top strap was to be anchored to the rear parcel shelf of a car or the tonneau floor of a station waggon; in front seat installations it was attached to the buckle tongue of the centre-rear seat belt.

Specified Occupant Range

Mass : 20 lb to 40 lb

Stature : Not exceeding 40 inches

APPRAISAL OF CHILD RESTRAINING DEVICE

Subject

General Motors "Love" Child Seat.

Comment

The "Love" seat was a part-upholstered, moulded plastic shell with integral harness. According to the instructions supplied by the manufacturer, it was intended for installation in either front or rear seating positions of vehicles fitted with seat belts, the seats of which were capable of resisting their own crash loads as specified by ADR 3. In particular, the seat was intended for use in a specified range of General Motors - Holden vehicles though it could be fitted to some vehicles of other manufacture.

The "Love" seat utilised the adult's seat belt of the relevant seating position for anchorage; this was supplemented by a top anchorage strap, permanently attached to the seat shell which, in rear seat installations, attached via a spring clip to a fitting which was bolted to the parcel shelf, or the tonneau floor in station waggon applications. Front seat installations required the top anchorage strap to be hooked by its spring-clip fitting to the slotted buckle tongue of the centre rear lap belt. The top anchorage strap could not therefore be fitted in the front seat of any vehicle that had seat belt buckles fitted with split tongues.

Installation of the restraint was relatively simple in all configurations by comparison with many approved child restraints which require that three or more anchor fittings be bolted to the vehicle structure. It was necessary however to ensure that when tightened, the buckle of the anchoring lap or lap/sash belt did not ride on the edge of the seat shell in a position such that its tilt-lock adjuster was rendered ineffective. It was noted that when a securing lap/sash belt was tightened in position on the seat, the webbing tended to "rope" in the vicinity of the buckle tongue. We did not consider this to be detrimental to belt strength in this instance but, in the case of a belt which is alternately used for anchoring the "Love" seat and for adult restraint it was possible that the wear rate could be increased.

Harness adjustment was found to be a simple procedure; all adjusters were readily accessible on the front of the harness when occupied. If installed as specified however, the anchoring seat belt had to be unfastened to gain access to the buckle and the lap belt adjuster.

Fitting trials using the Sierra "Toddler" 50th percentile, 3 year old dummy indicated that this was the largest occupant which could be accommodated by the "Love" seat; only 6 mm lateral clearance existed at the dummy's shoulder. Since this dummy's mass was 14.2 kg (31 lb) we were dubious of the manufacturer's statement that the seat could accommodate children of up to 40 lb mass. Local data concerning stature of children[25] indicated that 40 lb mass corresponded to a 50th percentile 4½ year old. Similarly the stated maximum height of 40 inches corresponded to a 50th percentile 4 year old whose mass would be 38 lb. Our belief was reinforced by the fact that the 40 lb body form successfully used for static strength testing of all SAA-approved child seats could not be fitted in the "Love" seat without being modified to reduce its shoulder breadth; also by the fact that shoulder strap slots were below the location required by AS E46 for a 40 lb dummy.

Webbing geometry was well suited to the "3 year old" dummy and also to the "6 month old" dummy. The range of adjustment available permitted the lap strap to be located to bear directly on the pelvis in each case; shoulder straps being laid out in "vee" pattern, intersecting at the centre buckle, ensured that the torso of the occupant was well restrained. We were alarmed that the crotch strap and shoulder straps, being mechanically connected to each other but not anchored to the shell, could be located to configurations that were badly out of adjustment, i.e. the crotch strap could be lengthened at the expense of the shoulder straps, simply by pulling it upwards. Since the lap strap was also connected to the crotch/shoulder strap assembly by passing through a loop in the latter, it was possible for the portion of lap strap beneath the seat to be pulled up to 100 mm ahead of its anchor slots in the seat shell. The potential thus existed for re-alignment of the belt to introduce excessive slack in the lap belt, or for crash loads to cause the shell to tear. We considered that the harness adjustment could be greatly improved by fixing the crotch strap/shoulder strap assembly to the rear face of the seat shell.

When the "Love" seat was installed in a typical seating position in the manner required by the manufacturer's instruction sheet and occupied by the "3 year old" dummy, it was found that the lap portion of the anchoring seat belt lay directly above and in contact with the child restraint's lap belt and buckle. We did not consider this to be in accordance with the requirements of AS E46 which stated that any material of stiffness greater than that specified for the child's harness should be regarded as a rigid Component; also that no rigid component should be included in locations where it could cause injury to the wearer during an accident. We believed: firstly, that the adult webbing itself must be classified as a rigid object and thus constituted a hazard to the "Love" seat's occupant by virtue of its excessive stiffness and possibly hazardous location on the occupant's body; secondly that it could cause injury by pushing the child restraint's buckle into the occupant's abdomen.

In view of our misgivings in regard to the recommended location of the adult's lap belt, an alternative location was evaluated. In this case the adult's lap belt passed around the base of the seat, thus permitting the occupant to be installed and removed without the necessity of unfastening the securing seat belt, and eliminating any tendency for it to cause injury to the occupant. The modified anchorage configuration was found to retain the "Love" seat equally as well as the recommended location - space requirements in particular were not significantly different in either case. During one simulation (74-048), a side impact with the adult's belt slack, the "Love" seat did partly separate from the securing belt when the corner of the seat shell moulding contacted the buckle and fractured. We did not consider this to be a representative defect, however; the shell had been cracked in previous testing (74-042) in the GM recommended configuration but had been restrained. We considered that consideration should be given to stiffening the seat shell at its lower corners to reduce the danger of fracture caused by buckle contact in side impact.

An examination of the peak forces recorded in the child restraint harness indicated that restraint lap belt load was substantially less in the manufacturer's specified arrangement than in our modified configuration where the adult belt did not contact the child. It was concluded that the adult lap belt took a large part of the restraint load. A comparison of webbing loads with and without the adult lap belt is shown in the following table:

ANCHORAGE CONFIGURATION	LAYOUT OF ANCHORING LAP BELT	RUN NO.	CHILD'S PELVIC STRAP FORCES (kN) (SUMMED)	HARNESS SHOULDER STRAP FORCES (kN) (SUMMED)	PELVIC DISPLACEMENT (m)
Lap belt plus parcel shelf strap	GM. Recommended	74-028	.59	1.38	.29
	TARU Modified	74-027	1.46	1.59	.37
	Variation		.87	.21	
Lap/sash belt plus parcel shelf strap	GM. Recommended	74-029	.62	1.54	.32
	TARU Modified	74-031	2.38	2.08	.31
	Variation		1.76	.54	

Assuming that the crotch strap forces do not differ significantly for the two anchorage layouts, and this is supported by the similarity of pelvic displacement in each case, it is reasonable to assume that the force applied by the adult lap belt is at least equivalent to the variation in harness lap belt load.

In all our frontal dynamic crash simulations the dummy was effectively restrained within the confines of an undamaged vehicle structure. Lateral simulations indicated the danger of contact of limbs with the inside surface of the vehicle, when the belts were slack; when tightly adjusted the occupant was restrained within the vehicle. At all times the head restraint proved particularly effective, at no time did the head move out of the protective enclosure.

Occupant kinematics in frontal simulations were similar to those observed in other bucket type seats; there was sometimes a tendency towards submarining of the dummy which was apparently checked by the crotch strap. We were unable to determine whether deletion of the crotch strap would have permitted gross submarining, since the centre buckle of the harness was part of this strap. Neither was it practicable to fit a transducer to the crotch strap owing to lack of space and the risk of damage to the dummy. Torso restraint was quite adequate. No motion was observed in the crotch strap/shoulder strap loop.

Peak loads in the harness straps were found to be quite low in comparison to some approved devices, even when the adult lap belt made no contribution to restraint. It was noted furthermore that lower loads were observed when the "Love" seat was restrained by a lap belt only, rather than a lap/sash belt. Thiswas probably because of rotational loadings being introduced by the sash component.

We considered that the G.M. "Love" seat would have failed to satisfy the requirements of AS E46 because, in the manufacturer's recommended installation, the occupant would be partly restrained by the anchoring seat belt, which must be classified as a rigid object. Furthermore it would have to be shown that the harness webbing complied with AS E47, and that the assembly could withstand the static loading test required by AS E46-1970.

Simulations reported in this Appendix indicate that the child seat performed quite satisfactorily in an alternative anchorage configuration with the anchoring belt around the seat base. It is possible that the device would satisfy all requirements of the standard in this form.

SUMMARY OF DYNAMIC TEST RESULTS FOR UNAPPROVED CHILD RESTRAINT

Type

General Motors "Love" Child Restraining Seat.

Test Procedure

The restraining device was initially subjected to frontal and lateral dynamic crash simulations in each of four possible passenger car installations specified by the manufacturer.

(a) Centre of rear seat. Secured by adult's lap belt around mid-section plus top strap anchored to parcel shelf.

(b) Outer rear seat. Secured by adult's lap/sash belt with lap portion over mid-section of device sash portion behind device; top strap anchored to parcel shelf.

(c) Centre of front bench seat. Secured by adult's lap belt around mid-section of device plus top strap picking up buckle tongue of centre-rear lap belt.

(d) Nearside front seat. Secured by adult's lap/sash belt with lap portion over mid-section of device, sash portion behind device; top strap picking up buckle tongue of centre-rear lap belt.

Where possible in the lap/sash anchorage cases, lateral simulations were carried out both with the sash anchorage on the side of the seat nearest impact and on the side remote from impact. Station waggon rear seat installation was not subjected to crash simulation, it being considered that, for the purposes of this report, the installation did not differ in great degree from the passenger car rear seat installation. It was noted that the location of an adult's belt across the mid-section of the device was not in accord with the requirements of AS E46 - this is discussed in depth in the Comment Section of this Appraisal. However the design of the device appeared to permit an alternative method of anchorage by passing the lap belt around the base of the shell, just beneath the occupant's knees.

The range of simulations listed above was therefore repeated in the alternative anchorage configurations.

All simulations were conducted using a Sierra "Toddler" dummy. Each simulation was performed with all straps adjusted tightly then repeated with 75 mm of slack introduced at each adjustment point.

Webbing force transducers were fitted to all straps which were part of the child restraint with the exception of the crotch strap where the necessary space was not available. The peak webbing forces are presented in the table overleaf together with sled deceleration data and the space requirements for the device and its occupant, obtained from analysis of high speed cinematographs of the occupant kinematics.

It should be noted that the estimates of space available, in the table, were based upon installation of the restraining device in the centre of the relevant seating position of the vehicle specified. Longitudinal space available for front seat installations was computed with the seat adjusted fully forward. In the case of this device only, the space available was presented for two General Motors vehicles in addition to those normally presented. The vehicles were a 1973 Holden HQ and a 1973 Holden Torana.

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in centre rear seat of Holden 'HQ' by adult's lap belt plus parcel shelf strap. Lap belt located around mid section of restraint.

Collision Aspect	Frontal		Lateral
Harness Adjustment	Tight	Slack	
Sample Condition	Used, undamaged.		
Run Number	74-028	74-068	
Sled Deceleration Data			
Velocity Change	39.8	39.1	
Peak Deceleration (m/s^2)	170	170	
Pulse Duration (ms)	101	100	
Webbing Force Data			
R.H. Shoulder (kN)	.83	.79	NOT TESTED.
L.H. Shoulder (kN)	.55	.80	
R.H. Lap (kN)	.30	.48	
L.H. Lap (kN)	.29	.49	
Crotch Strap (kN)	Not Measured		
Space Requirements			
Head (m)	.37		
Shoulder (m)	.20		
Pelvis (m)	.29		
Hand (m)	.58		
Foot (m)	.82		
Space Available			
Holden HQ (m)	.66		.69
Holden Torana (m)	Could not be fitted; no centre seat belt		
Ford Falcon (m)	.66		.80
VW Beetle (m)	Could not be fitted; no centre seat belt		
Morris Mini (m)	Could not be fitted; no centre seat belt		

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in centre rear seat of Holden 'HQ' by adult's lap seat belt plus parcel shelf strap. Lap belt around base of restraint.

Collision Aspect	Frontal		Lateral	
Harness Adjustment	Tight	Slack	Tight	Slack
Sample Condition	Used,	Repaired		
Run Number	74-027	74-070		
Sled Deceleration Data				
Velocity Change (km/h)	40.2	38.8		
Peak Deceleration (m/s^2)	173	169		
Pulse Duration (ms)	102	101		
Webbing Force Data				
R.H. Shoulder (kN)	.81	.93	NOT TESTED	
L.H. Shoulder (kN)	.78	.88		
R.H. Lap (kN)	.87	1.11		
L.H. Lap (kN)	.59	1.07		
Crotch Strap (kN)	Not Measured			
Space Requirements				
Head (m)	.40			
Shoulder (m)	.23			
Pelvis (m)	.37			
Hand (m)	.59			
Foot (m)	.85			
Space Available				
Holden HQ (m)	.66		.69	
Holden Torana (m)	Could not be fitted; no centre seat belt			
Ford Falcon (m)	.66		.80	
VW Beetle (m)	Could not be fitted; no centre seat belt			
Morris Mini (m)	Could not be fitted; no centre seat belt			

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat

Configuration of Device: Secured in outboard rear seat of Holden 'HQ' by lap/sash seat belt plus parcel shelf strap. - Lap belt around mid section of restraint.

Collision Aspect	Frontal		Lateral			
Sash Anchorage	-		Near to Impact		Remote from Impact	
Harness Adjustment	Tight	Slack	Tight	Slack	Tight	Slack
Sample Condition	—— Used,	Undamaged	——————			Repaired
Run Number	74-029	74-066	74-044	74-047	74-043	74-055
Sled Deceleration Data						
Velocity Change (km/h)	41.1	40.2	41.5	39.5	41.8	40.0
Peak Deceleration (m/s^2)	179	176	185	173	187	177
Pulse Duration (ms)	101	101	98	98	98	97
Webbing Force Data						
R.H. Shoulder (kN)	.83	.67	.39	.44	.23	.44
L.H. Shoulder (kN)	.71	.85	.44	.64	.43	.63
R.H. Lap (kN)	.33	.22	.19	.09	.18	.10
L.H. Lap (kN)	.29	.59	.30	.06	.39	.04
Crotch Strap (kN)	Not Measured					
Space Requirements						
Head (m)	.40		.41	.69	.41	.59
Shoulder (m)	.21		.44	.56	.42	.55
Pelvis (m)	.32		.35	.61	.38	.48
Hand (m)	.60		.76	.87	.72	.87
Foot (m)	.87		.86	1.03	.87	.92

Space Available

	Frontal	Lateral
Holden HQ (m)	.66	.37
Holden Torana (m)	.63	.28
Ford Falcon (m)	.66	.40
VW Beetle (m)	.49	.30
Morris Mini (m)	.63	.33

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in outboard rear seat of Holden 'HQ' by lap/sash belt plus parcel shelf strap - Lap belt around base of restraint.

Collision Aspect	Frontal		Lateral			
Sash Anchorage	-		Near to Impact		Remote from Impact	
Harness Adjustment	Tight	Slack	Tight	Slack	Tight	Slack
Sample Condition	Used, undamaged					
Run Number	74-031	74-067	74-045	74-046	74-042	74-048
Sled Deceleration Data						
Velocity Change (km/h)	40.0	39.8	40.6	39.8	not recorded	40.5
Peak Deceleration (m/s^2)	177	173	181	173	194	175
Pulse Duration (ms)	101	101	98	98	110 (No Computer Data Results from CRO)	99
Webbing Force Data						
R.H. Shoulder (kN)	1.12	-	.52	.64	.36	.35
L.H. Shoulder (kN)	.96	.90	.56	.80	.53	1.27
R.H. Lap (kN)	1.08	.90	.77	.85	.85	.07
L.H. Lap (kN)	1.30	1.19	1.68	2.48	not measured	.09
Crotch Strap (kN)	Not Measured					
Space Requirements						
Head (m)	.52		.45	.65	.50	.60
Shoulder (m)	.33		.48	.64	.46	.60
Pelvis (m)	.31		.37	.61	.44	.59
Hand (m)	.70		.78	.95	.76	.87
Foot (m)	.88		.94	1.06	.83	1.03

Space Available

	Frontal	Lateral
Holden HQ (m)	.66	.37
Holden Torana (m)	.63	.28
Ford Falcon (m)	.66	.40
VW Beetle (m)	.49	.30
Morris Mini (m)	.63	.33

TABLE OF RESULTS OF CRASH SIMULATION

Subject   General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in centre front seat of Holden 'HQ' by adult's lap seat belt plus top strap picking up rear centre seat belt buckle tongue. Lap belt around mid section of restraint.

Collision Aspect	Frontal		Lateral	
Harness Adjustment	Tight	Slack	Tight	Slack
Sample Conditions	Repaired		Repaired	
Run Number	74-074	74-071	74-063	74-062
Sled Deceleration Data				
Velocity Change (km/h)	38.5	38.4	38.5	38.5
Peak Deceleration (m/s^2)	163	166	167	168
Pulse Duration (ms)	102	101	100	99
Webbing Force Data				
R.H. Shoulder (kN)	.55	.74	.32	.37
L.H. Shoulder (kN)	.65	.78	.52	.58
R.H. Lap (kN)	.37	.39	.38	.28
L.H. Lap (kN)	.28	.37	.10	.04
Crotch Strap (kN)	Not Measured		Not Measured	
Space Requirements				
Head (m)			.46	.71
Shoulder (m)			.42	.65
Pelvis (m)			.40	.49
Hand (m)			.75	.91
Foot (m)			.79	.94
Space Available				
Holden HQ (m)	.76		.71	
Holden Torana (m)	Could not be fitted; no centre rear seat belt			
Ford Falcon (m)				
VW Beetle (m)	Could not be fitted; no centre rear seat belt			
Morris Mini (m)	Could not be fitted; no centre rear seat belt			

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in centre front seating position of Holden 'HQ' by adult's lap seat belt around base plus top strap picking up rear centre seat belt buckle tongue.

Collision Aspect	Frontal		Lateral	
Harness Adjustment	Tight	Slack	Tight	Slack
Sample Condition	Repaired		Repaired	
Run Number	74-073	74-072	74-064	74-061
Sled Deceleration Data				
Velocity Change (km/h)	38.6	38.4	38.3	38.7
Peak Deceleration (m/s^2)	163	167	167	169
Pulse Duration (ms)	102	102	100	99
Webbing Force Data				
R.H. Shoulder (kN)	.72	.89	.29	.50
L.H. Shoulder (kN)	.75	.93	.53	.43
R.H. Lap (kN)	.72	1.04	.88	.90
L.H. Lap (kN)	.74	1.18	.22	.21
Crotch Strap (kN)	Not Measured		Not Measured	
Space Requirements				
Head (m)			.48	.72
Shoulder (m)			.46	.66
Pelvis (m)			.40	.56
Hand (m)			.77	.94
Foot (m)			.88	1.00
Space Available				
Holden HQ (m)	.76		.71	
Holden Torana (m)	Could not be fitted; no centre rear seat belt			
Ford Falcon (m)				
VW Beetle (m)	Could not be fitted; no centre rear seat belt			
Morris Mini (m)	Could not be fitted; no centre rear seat belt			

TABLE OF RESULTS OF CRASH SIMULATION

Subject General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in front left hand seat of Holden 'HQ' by lap/sash seat belt with lap component around mid section of device. Top strap picking up rear centre seat belt buckle tongue.

Collision Aspect	Frontal		Lateral		
Sash Anchorage			Near to Impact		Remote from Impact
Harness Adjustment	Tight	Slack	Tight	Slack	
Sample Condition	Repaired		Repaired		
Run Number	74-076	74-077	74-056	74-059	NOT TESTED. TEST RIG COULD NOT BE SUITABLY MODIFIED.
Sled Deceleration Data					
Velocity Change (km/h)	38.1	37.5	39.6	37.2	
Peak Deceleration (m/s^2)	161	161	174	162	
Pulse Duration (ms)	102	103	99	100	
Webbing Force Data					
R.H. Shoulder (kN)	.48	.70	.26	.35	
L.H. Shoulder (kN)	.51	.61	.28	.26	
R.H. Lap (kN)	.39	.30	.14	.03	
L.H. Lap (kN)	.38	not recorded	.10	.05	
Crotch Strap (kNO	Not Measured		Not Measured		
Space Requirements					
Head (m)			.47		
Shoulder (m)			.49		
Pelvis (m)			.47		
Hand (m)			.80		
Foot (m)			.94		
Space Available					
Holden HQ (m)	.76			.32	
Holden Torana (m)	Could not be fitted; no centre rear seat belt				
Ford Falcon (m)					
VW Beetle (m)	Could not be fitted; no front centre seating position				
Morris Mini (m)	Could not be fitted; no front centre seating position				

TABLE OF RESULTS OF CRASH SIMULATION

Subject. General Motors "Love" Child Restraining Seat.

Configuration of Device: Secured in front left hand seat of Holden 'HQ' by lap/sash seat belt with lap component around base of restraint. Top strap picking up rear centre seat belt buckle tongue.

Collision Aspect	Frontal		Lateral		
Sash Anchorage			Near to impact		Remote from impact
Harness Adjustment	Tight	Slack	Tight	Slack	
Sample Condition	Repaired		Repaired		
Run Number	74-075	74-078	74-057	74-058	NOT TESTED. TEST RIG COULD NOT BE SUITABLY MODIFIED.
Sled Deceleration Data					
Velocity Change (km/h)	38.7	37.1	36.4	37.0	
Peak Deceleration (m/s^2)	163	159	163	163	
Pulse Duration (ms)	102	102	100	99	
Webbing Force Data					
R.H. Shoulder (kN)	.69	.90	.45	.57	
L.H. Shoulder (kN)	.68	.76	.42	.57	
R.H. Lap (kN)	.82	.59	.88	.59	
L.H. Lap (kN)	.70	1.16	.38	.43	
Crotch Strap (kN)	Not Measured		Not Measured		
Space Requirements					
Head (m)			.48	.67	
Shoulder (m)			.49	.63	
Pelvis (m)			.46	.58	
Hand (m)			.84	.93	
Foot (m)			.92	.97	

Space Available

	Frontal	Lateral
Holden HQ (m)	.76	.32
Holden Torana (m)	Could not be fitted; no centre rear seat belt	
Ford Falcon (m)		
VW 'Beetle' (m)	Could not be fitted; no front centre seating position	
Morris Mini (m)	Could not be fitted; no front centre seating position	

APPENDIX No. 12

STEELCRAFT C45 CAR SEAT

Photograph

TARU Negative 428-16

Description

A framed seat with integral restraint harness and "hooked" extensions on upper rear surface to permit suspension from backrest of a free standing car seat.

The seat was foldable for storage and had a lightly padded steel guard rail surrounding the child at waist height.

The seat was not SAA-approved.

Connection to Car

No anchorage kit was supplied with the seat.

Makers instruction sheet stated that adult lap or lap/sash belts could be used to restrain the child seat *"for added safety"*.

Specified Occupant Range

Not specified on packaging or instruction sheet.

APPRAISAL OF CHILD SEAT

Type

Steelcraft C45 car seat.

Comment

This device appeared to rely upon its tubular steel "hooks" to restrain it and its occupant, the assumption being implicit that the vehicle seat was strong enough to react the loads applied. Our simulations showed that even in cases where the car seat was strong enough to withstand the child seat's deceleration forces, the hooks did not provide adequate restraint. In the case of the Torana folding bucket seat, the backrest remained in position and deflected only slightly, but the child seat flailed forward and upward and a child would have certainly impacted the internal surfaces of the vehicle at several points. In the case of the Morris Mini installation, the vehicle seat was not provided with a catch to lock it in position. During the crash simulation the seat tilted forwards and the child seat became almost entirely detached. In this case the dummy would have impacted the dash panel and windscreen of the vehicle.

In both our simulations the dummy remained strapped to the child seat but the seat itself suffered major damage. In both cases the backrest became detached, the seat pad broke across its leading edge and distortion occurred in the tubular frames.

Inspection of the child seat indicated that it would fail to satisfy the requirements of AS E46-1970 on, at least, the following points:

(a) The restraint had no means of attachment to a vehicle.

(b) Padding on the guard rail did not comply with SAA requirements for padding of body restraining enclosures.

Further to these points, it would have been necessary to show that the restraint could pass the static loading test of AS E46-1970.

Adjustment of the child seat's harness was relatively easy. We are unable to comment on the efficacy of the harness itself owing to the collapse of the seat structure during crash simulation, thus rendering the harness redundant.

SUMMARY OF DYNAMIC TEST RESULTS FOR UNAPPROVED CHILD SEAT

Seat Type: Steelcraft C45 car seat.

Test Procedure

The child seat was tested in the following configurations:

(a) Hooked over backrest of Holden "Torana" bucket seat (backrest locked).

(b) Hooked over backrest of Morris Mini deluxe bucket seat (non-locking type).

The Sierra "Toddler" dummy was used in each instance; the harness was adjusted tightly.

Only the frontal crash situation was examined.

It was not known whether this seat would survive crash simulation without sustaining mechanical failure. Accordingly no webbing force transducers were fitted.

Sled deceleration data and space requirements are presented in the table overleaf.

TABLE OF DYNAMIC TEST RESULTS - STEELCRAFT C45

TEST CONFIGURATION	RUN NUMBER	SLED DECELERATION: VELOCITY CHANGE km/h	SLED DECELERATION: PEAK DECELERATION m/s^2	SLED DECELERATION: PULSE DURATION ms*	SPACE REQUIREMENT m.	SPACE AVAILABLE m.	OBSERVATIONS
Torana bucket seat Sierra "Toddler"	74-004	38.9	168	100	Head : .66 Shoulder: .48 Hand : .94 Foot : .90 Pelvis : .34	.66	Backrest of Torana seat suffered slight permanent deformation. Dummy and seat swung upwards pivoting about 'hook' anchorage point.
Morris Mini bucket seat Sierra "Toddler"	74-005	41.0	181	98	Head : .95 Shoulder: .83 Hand :1.50 Foot :1.0 Pelvis :1.70	.73	Dummy and child seat partially ejected. Mini bucket seat upholstery torn. Child seat extensively damaged.

* Duration is portion of pulse above 10% of peak deceleration.

APPENDIX No. 13

STEELCRAFT C52 'MAJESTIC' CHILD SEAT

Photograph

TARU Negative 437-12

Description

Reclinable framed seat with protruding "skid" tubes for location between seat base, cushion and backrest. It was foldable for storage and had a lightly padded steel tubular rail in front of the child. The rail hinged upward but was normally held in position by a soft plastic crotch strap. A restraint harness was integral with the seat.

This seat was not approved by SAA.

Connection to Car.

As supplied, there was no means of securing this seat to the vehicle structure, other than its projecting skids. A Steelcraft parcel anchorage kit was available as a separate accessory but no such anchorage kit was available for the lower end of the seat.

Specified Occupant Range

Not specified on packaging or instruction sheet.

APPRAISAL OF CHILD SEAT

Type

Steelcraft C52 "Majestic".

Comment

The unapproved C52 child seat bore a passing resemblance to the Steelcraft C54 and Micklem 674 approved restraint devices. We consider this to be of concern in that the C52 could be mistakenly selected as an approved device by the unwary purchaser.

The instruction leaflet supplied with this seat was inadequate. It implied that normal vehicle installation requires only that the rearwards projecting "skid" rails be pushed firmly between seat and backrest (Fig. 1), a situation which our simulations have shown to be ineffective in the case of a crash. *"For added safety"*, the leaflet stated that an adult lap belt or lap/sash combination belt could be used to hold the child seat in place. The diagram illustrating this latter case showed the adult sash belt lying over the top of the child seat harness. We assumed this arrangement to have been drawn in error and did not attempt a crash simulation.

The instruction leaflet carried no reference to the Steelcraft parcel shelf restraint straps.

When properly anchored by an adult lap/sash seat belt assembly, or a lap belt plus the parcel shelf strap, we found the Steelcraft C52 seat to restrain the occupant though the risk existed of his limbs or head impacting the "guard rail" particularly when the harness was not tightly adjusted. Even with the seat in the reclined position, the dummy was restrained. In this case the seat suffered some distortion of its frame.

It should be pointed out that the "guard rail" was removable without tools. We would recommend such removal if the seat were to be installed in a car.

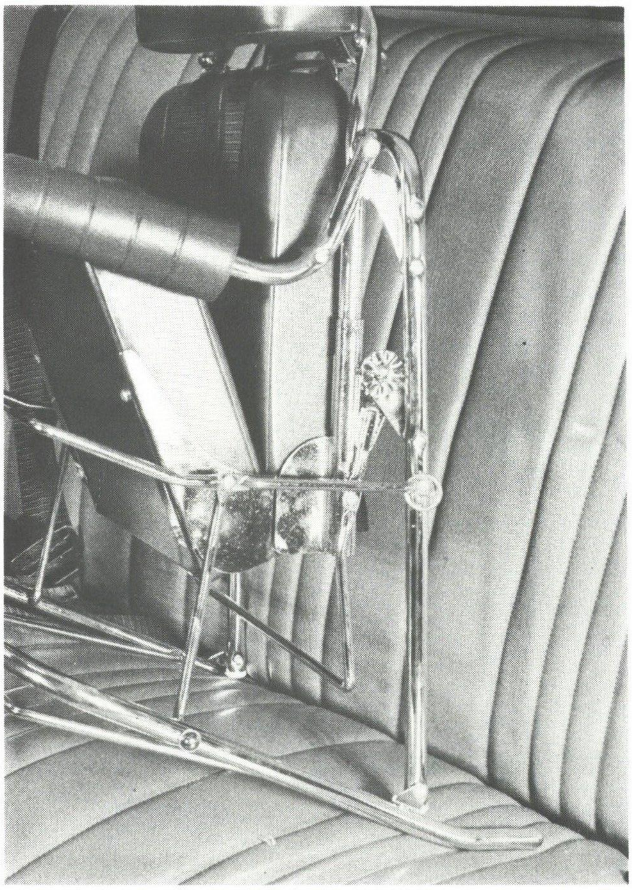


FIGURE 1

Detail of "skid" rails.

Steelcraft C52

TARU Negative
428-05

We do not consider the seat to provide adequate restraint when secured by a lap belt only or by the parcel shelf strap only.

Some submarining was evident in Runs 73-228 and 73-243. We consider this to be attributable to the collapse of the leading edge of the seat squab which occurred in both cases, allowing the dummy to slip beneath the lap belt. The steel frame of the seat did not extend to this area.

Adjustment of the harness was relatively easy and once adjusted the restraint remained tight. All adjusters were accessible even when the seat was anchored by an adult lap sash belt.

No significant slip was noted in the harness adjusters in the cases where the dummy was adequately restrained.

We consider that this seat would fail to meet the requirements of AS E46 in at least the following respects:

(a) The device was not provided with means for attachment to a vehicle.

(b) The padding on the guard rail did not comply with the requirements of AS E46 for padding of body restraining or head restraining enclosures.

Further to these points, compliance would have required it to be shown that the restraint would pass the static loading test of AS E46-1970.

SUMMARY OF DYNAMIC TEST RESULTS FOR CHILD SEAT

Seat Type : Steelcraft C52, "Majestic" reclining car seat and nursery chair.

Test Procedures.

The child seat was tested in the following configurations:

(a) No anchorage, seat in upright position.

(b) Seat in upright position anchored by adult lap belt only.

(c) Seat in upright position anchored by adult lap/sash belt.

(d) Seat in upright position anchored by adult lap belt and Steelcraft parcel shelf strap.

(e) Seat in upright position anchored by Steelcraft parcel shelf strap only.

(f) Seat reclined, anchored by adult lap/sash belt.

In all cases the Sierra "Toddler" dummy was used. The harness was adjusted tightly.

Only the frontal collision aspect was examined.

Owing to the risk of mechanical failure and subsequent damage to instrumentation, no force transducers were fitted to the harness.

Sled deceleration data and space requirements are presented in the table overleaf.

TABLE OF DYNAMIC TEST RESULTS - STEELCRAFT C52

CONFIGURATION OF DEVICE	RUN NUMBER	SLED DECELERATION VELOCITY CHANGE km/h	PEAK DECELERATION m/s^2	DURATION ms *	SPACE REQUIREMENT m.	SPACE AVAILABLE m.	OBSERVATIONS
a. No anchorage	73-231	40.6	176	100	Not measurable	0.58 m Morris Mini Deluxe 0.45 m Volkswagen 1600 Superbug 0.57 m Ford Falcon	Seat and dummy ejected from rig.
b. Anchored by adult lap belt	73-229	39.4	172	100	Head : .84 Shoulder: .63 Hand : .99 Foot : .95 Pelvis : .48		Seat and dummy jack-knifed but dummy was not ejected. Base frame of seat was deformed, back rest broke off. Dummy's face impacted guard rail
c. Anchored by adult lap/ sash belt	73-242	39.4	169	102	Head : .42 Shoulder: .28 Hand : .59 Foot : .89 Pelvis : .17		The dummy was restrained, face impacted guard rail, no apparent damage to seat.
d. Anchored by adult lap belt + parcel shelf strap	73-228	39.8	172	101	Head : .27 Shoulder: .14 Hand : .47 Foot : .86 Pelvis : .20		Some submarining evident but dummy was not ejected. Dummy's face impacted guard rail. No apparent damage to seat.
e. Anchored by parcel shelf strap only	73-230	40.2	174	101	Head : .38 Shoulder: .18 Hand : .54† Foot : .95 Pelvis : .33		Seat and dummy swung upward, pivoting about parcel shelf anchorage point. Dummy submarined, face impacted guard rail. Leading edge of seat broke. † Space requirements measured at point at which it is estimated that occupant would have impacted car roof.

* Duration is portion of pulse above 10% of peak deceleration.

TABLE OF DYNAMIC TEST RESULTS - STEELCRAFT C52 (Cont.)

CONFIGURATION OF DEVICE	RUN NUMBER	SLED DECELERATION VELOCITY CHANGE km/h	PEAK DECELERATION m/s^2	DURATION ms*	SPACE REQUIREMENT m.	SPACE AVAILABLE m.	OBSERVATIONS
f.							
Seat reclined, anchored by adult lap/ sash belt.	73-243	40.0	172	100	Head : .45 Shoulder: .28 Hand : .50 Foot : .91 Pelvis : .89	0.58 m Morris Mini Deluxe 0.45 m Volkswagen 1600 Superbug 0.57 m Ford Falcon	Dummy's face impacted guard rail and caused it to detach, seat squab broke, backrest distorted. Dummy was restrained. Some submarining.

APPENDIX No. 14

Guardwell CS200 Child Restraint

Photograph

TARU Negative 437-18

Description

Forward facing moulded plastic enclosure with padded surface in front of occupant. The design was such that restraint was provided without the use of a harness.

The device was not approved by SAA.

Connection to Car

Anchored by adult's seat belt; lap belt only or lap/sash.

Specified Occupant Range

Mass : 20 lb to 50 lb.

Stature: Not greater than 40 inches.

APPRAISAL OF CHILD RESTRAINING DEVICE

Type

Guardwell CS200 child seat.

Comment

This Guardwell seat was a plastic moulding in the form of an enclosure with an integral seat. It was designed to be placed upon an existing vehicle seat surface and anchored by an existing seat belt. No harness was included in the design, the enclosure itself being intended to provide all restraint. The surface of the enclosure directly in front of the occupant was covered with plastic padding; it did not appear that this material would comply with the requirements for head restraining padding specified by AS E46 because its thickness was ½ inch in comparison with the 1½ inches specified.

Installation of the unoccupied device was relatively simple, though it proved difficult to subsequently install the dummy occupant. We found it necessary to disconnect the anchoring seat belt prior to installation or removal of the occupant.

It was also necessary to ensure, in order to prevent slippage through the tilt-lock adjuster, that when tightened the buckle of the anchoring seat belt did not ride on a corner of the moulding.

The capacity of the device was sufficiently large that it could accommodate either Sierra dummy; it appeared however that the 50 lb "Sammy" dummy was the largest which could readily be installed and it was thus unlikely that the device could have accommodated average children near the upper limit of the SAA's 40 to 80 lb class. We considered the device to be unsuitable for the very small child represented by the Unit's "Simon" six month old dummy because the size of this dummy was such that it would have almost certainly ejected through the lower opening of the device.

Dynamic crash simulations were concentrated on a configuration in which the Guardwell was secured by a lap/sash seat belt and occupied by the Sierra Toddler "3 year old". Some additional simulations were conducted using the Sammy dummy and some in an alternative lap-belt-only anchorage configuration.

Observations of high speed cinematographs indicated that the mode of restraint was unsatisfactory both in frontal and side impact. In frontal impact, the restraint loads appeared to be applied primarily to the soft abdominal area rather than to the pelvis and thoracic cage, indeed it appeared that the pelvis was not contacted at all in some cases. It was not considered likely that the padding provided would have mitigated this effect. In side impact the dummy had no support for its upper torso or head and thus appeared to be subjected to lateral flexing of the lumbar and cervical vertebra. Lateral shoulder excursions of 0.50 metre were recorded.

In frontal impacts the heads of both dummies invariably contacted the upper, padded surface of the enclosure. In the case of the Sammy "six year old", the eyebrows and nose contacted the relatively sharp leading edge.

The device restrained both dummies in all simulations and space requirements indicated that in frontal impact there was sufficient clearance for head and torso in all three cars provided that the securing seat belt was tightly adjusted. In side impact it was probable that head, shoulders and pelvis of either dummy would have contacted the vehicle sidewall if it had been initially seated in the outboard seating position. This location was the only one possible for the Volkswagen and the Mini since they did not have centre rear lap belt installations. The Falcon would have permitted central installation and in this case, with 0.8 m sideways space available, the clearance would still have been insufficient for the Sammy dummy, but just adequate for the Toddler, again providing the anchoring seat belt was tightly adjusted. This last estimate was based on measurements of the device anchored by a lap/sash belt with sash anchorage near to impact and remote from impact. We consider this to be conservative, in that excursions would have been greater when secured by a lap belt only.

When the device was anchored by a lap/sash seat belt, it was noted that a difference existed in space requirements according to which side was the closer to the impact. Where the sash anchorage was on the impact side of the dummy, excursion was less than if sash anchorage was remote from impact.

It was noted that in frontal impacts the "six year old" tended to eject over the top of the device, being prevented only by the wedging of the lower legs in the lower opening of the enclosure.

Comparison of simulations indicated differences in occupant kinematics according to whether anchorage was provided by lap or lap/sash belt. The sash component appeared to reduce excursion of the upper parts of the body and to increase excursion of the lower parts. This was probably the result of limitation of forward pitching of the device. Nevertheless, substantial pitching was observed during all impacts.

Placement of a dummy's arms inside the enclosure did not produce any significant change in kinematics from the case where they remained outside, other than the expected limitation of hand movement.

We consider that the Guardwell CS200 would have failed to meet the requirements of AS E46 in that:

(a) It was not adjustable to the requirement of the individual occupant.

(b) Deceleration forces were not distributed over chest and pelvis of the occupant.

Additionally, for compliance, it would require to be shown that the padding provided for body restraint complied with the relevant requirements of AS E46; also that the device was capable of withstanding the Standard's static strength test requirements.

SUMMARY OF DYNAMIC TEST RESULTS FOR CHILD RESTRAINT

Subject

Guardwell CS200 child seat

Test Procedure

The device was subjected to frontal and lateral crash simulations in a typical motor vehicle rear seat installation. The following configurations were examined:

(a) Anchored by adult's lap/sash seat belt; occupied by simulated three year old child.

(b) Anchored by adult's lap/sash seat belt; occupied by simulated six year old child.

(c) Anchored by adult's lap belt; occupied by simulated three year old child.

(d) Anchored by adult's lap belt; occupied by simulated six year old child.

Not all possible variations of installation and occupant were tested. Simulations were restricted to those cases thought to be of greatest value.

Data recorded during the simulations are presented in the following tables.

TABLE 1

TABLE OF RESULTS OF CRASH SIMULATIONS

Subject Guardwell CS200 child restraint.

Configuration of Device: Installed in typical rear seat. Anchored by adult's lap/sash seat belt. Occupant, Sierra "Toddler"

Collision Aspect	Frontal		Lateral			
Sample Condition	used, undamaged					
Sash Anchorage			Near to Impact		Remote from Impact	
Run Number	74-041		74-053	74-054	74-049	74-050
Anchorage Adjustment	Tight	Slack	Tight	Slack	Tight	Slack
Sled Deceleration Data						
Velocity Change (km/h)	40.8		39.3	39.1	40.3	40.1
Peak Deceleration (m/s^2)	179		174	172	177	176
Pulse Duration (ms)	100		98	98	98	99
Space Requirements						
Head (m)	.40	not tested	.55	.63	.79	.87
Shoulder (m)	.32	not tested	.50	.54	.68	.62
Pelvis (m)	.40	not tested	.40	.42	.52	.52
Hand (m)	.58	not tested	.83	.88	.94	1.00
Foot (m)	.94		.76	.83	.71	.85
Space Available						
Ford Falcon (m)	.71			.40		
VW "Beetle" (m)	.54			.30	outboard seat	
Morris Mini (m)	.68			.33		

TABLE 2

TABLE OF RESULTS OF CRASH SIMULATIONS

Subject Guardwell CS200 child restraint.

Configuration of Device: Installed in typical rear seat anchored by adult's lap belt.

Collision Aspect	Frontal	Frontal	Frontal
Sample Condition	New	used, undamaged	used, undamaged
Occupant	Toddler	Toddler	Sammy
Run Number	74-035*	74-036*	74-037
Anchorage Adjustment	Tight	Tight	Tight
Sled Deceleration Data			
Velocity Change (km/h)	40.8	35.8	35.9
Peak Deceleration (m/s^2	183	172	168
Pulse Duration	100	94	96
Space Requirements			
Head (m)	.50	.56	.63
Shoulder (m)	.35	.34	.36
Pelvis (m)	.36	.34	.30
Hand (m)	.65	-	.73
Foot (m)	.81	.91	.87
Space Available			
Ford Falcon (m)		.71	
VW "Beetle" (m)		.54	
Morris Mini (m)		.68	

Notes * On run 74-035, the dummy's arms were placed outside the seat enclosure; on run 74-036 they were inside.

TABLE OF RESULTS OF CRASH SIMULATIONS

Subject Guardwell CS200 child restraint

Configuration of Device: Installed in typical rear seat installation by adult's lap/sash seat belt. Occupant Sierra "Sammy".

Collision Aspect	Lateral	
Sample Condition	used, undamaged	
Sash Anchorage	Remote from Impact	
Run Number	74-051	74-052
Anchorage Adjustment	Tight	Slack

Sled Deceleration Data

Velocity Change (km/h)	39.3	39.1
Peak Deceleration (m/s^2)	172	172
Pulse Duration (ms)	99	99

Space Requirements

Head (m)	.94	1.00
Shoulder (m)	.74	.80
Pelvis (m)	.43	.54
Hand (m)	1.04	1.10
Foot (m)	.90	.92

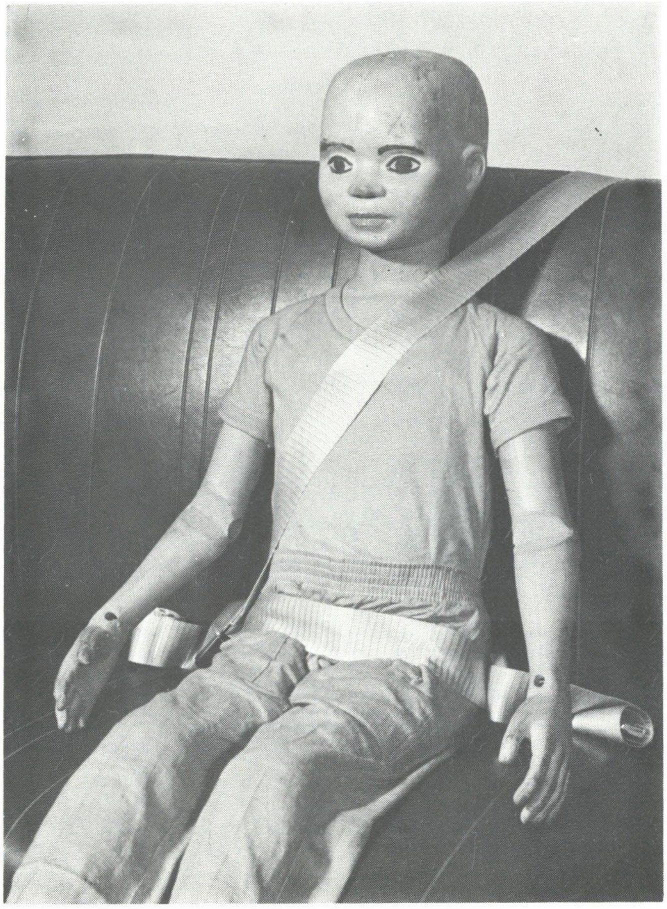
Space Available

Ford Falcon (m)	.40	
VW "Beetle" (m)	.30	outboard seat
Morris Mini (m)	.33	

APPENDIX No. 15

ADULT LAP/SASH BELT

Photograph



TARU Negative 400-02

APPRAISAL OF CHILD RESTRAINT

Type

Adult lap/sash belt

Comment

An adult lap/sash belt is provided in the outer seats of all cars currently being made in Australia. This makes the belt more available than any other restraining system.

Space measurements based on analyses of cinematographs indicated sufficient space within the three cars to prevent impact of the passenger with the back of the front seat, or the side of the car furthest from the passenger. However, impact of head and torso with the side of the car nearest to the passenger appeared likely to arise for collisions on that side.

The lap/sash belt appeared in the cinematographs to have been well located with the lap section low on the torso. The dummy's torso slipped out of the sash belt during the angle collision of 73172, but remained restrained in the similar test 73171 where the belt was adjusted more tightly.

The small child restrained by a lap/sash belt might complain of a lack of view from the vehicle in which he rides. Tests with an SAA-approved child harness indicated that the use of an unrestrained cushion to raise young passengers can promote submarining. Tests with a restrained soft cushion also indicated the possibility of submarining because of compression of the cushion.

Measurements of webbing tensions indicated greater loads in the sash strap (4.5 kN in test 73102) than in any of the shoulder straps of the SAA-approved child harnesses. We believe that this was due to the higher stiffness of the adult webbing, and would expect the reduction of injury by the use of adult belts to be less than with the more extensible webbing specified for SAA-approved child harnesses.

The current trend to fixed length seat belt straps sometimes limits the range of adjustment of a lap/sash belt. We noted that some lap/sash layouts could result in the lap belt restraining across the abdomen of a child instead of across the pelvis.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Adult lap/sash belt with "6 years" dummy with the buckle to the right side of the passenger.

Test

Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73101	73102	73169	73170		
New Sample?	Yes	No	No	No		
Sled Deceleration						
Change of Velocity (km/h)	39.3	38.9	38.6	39.4		
Peak Deceleration (m/s^2)	169	172	170	171		
Duration (ms above 10% of Peak)	102	101	100	100		
Peak Webbing Tensions (kN)						
R.H. Shoulder						
L.H. Shoulder (F_1)	3.9	4.5	1.5	4.0		
R.H. Lap ($F_{1,2}$)				3.8		
L.H. Lap (F_3)	1.9	1.9	2.9	2.0		
Crotch						

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.42	0.54	0.52	0.60
Shoulders	0.26	0.35	0.49	0.51
Pelvis	0.39	0.42	0.41	0.50
Hands	0.72	0.83	0.75	0.71
Feet	0.96	1.06	0.84	0.93

Space Availability (m)		
Morris Mini De-Luxe	0.62	0.84
Volkswagen 1600 Superbug	0.54	0.27
Ford Falcon	0.66	0.35

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Adult lap/sash belt with "6 years" dummy with the buckle to the the left side of the passenger.

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number			73171	73172		
New Sample?			No	No		
Sled Deceleration						
Change of Velocity (km/h)			38.5	37.4		
Peak Deceleration (m/s^2)			164	162		
Duration (ms above 10% of Peak)			101	101		
Peak Webbing Tensions (kN)						
R.H. Shoulder (F_1)			3.7	4.2		
L.H. Shoulder						
R.H. Lap (F_3)			2.0	2.8		
L.H. Lap ($F_{2\ 4}$)			2.0	2.7		
Crotch						

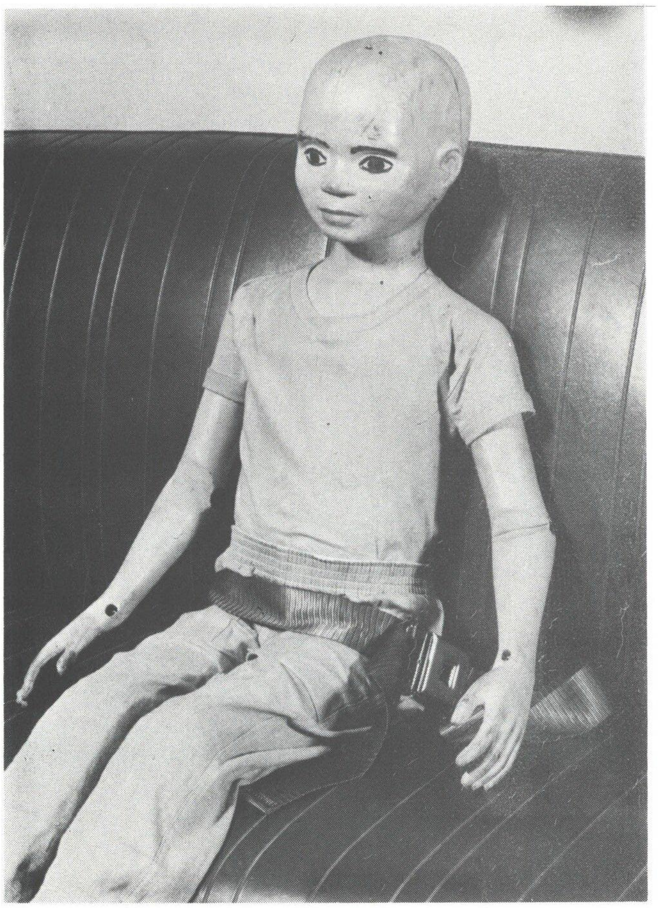
Space Requirements (m)	Sideways Space	
Head	0.53	0.80
Shoulders	0.44	0.65
Pelvis	0.42	0.46
Hands	0.76	0.87
Feet	0.81	0.84

Space Availability (m)	
Morris Mini De-Luxe	0.31
Volkswagen 1600 Superbug	0.90
Ford Falcon	1.25

APPENDIX No. 16

ADULT LAP BELT

Photograph



TARU Negative 400-09

APPRAISAL OF CHILD RESTRAINT

Type

Adult lap belt.

Comment

Adult lap belts are available in the centre positions of currently built 5 or 6 seater cars. They are not available in cars such as the Mini or Volkswagen.

For corner collisions in larger cars such as the Falcon, the lap belt appeared to restrain the dummy sufficiently to prevent head impact with the side of the car. However our measurements of space requirements indicated that in frontal impact, the head would impact the back of the front seat, even if the occupant was small, and the belt tightly adjusted. We therefore conclude that lap belts give poor crash protection compared with SAA-approved child restraints and lap/sash belts.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- Adult Lap Belt with "6 years" dummy

Test	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73099	73100	73173	73174		
New Sample?		No	No	No		
Sled Deceleration						
Change of Velocity (km/h)	39.0	39.4	40.4	40.0		
Peak Deceleration (m/s^2)	171	175	176	175		
Duration (ms above 10% of Peak)	100	100	99	99		
Peak Webbing Tensions (kN)						
R.H. Shoulder						
L.H. Shoulder						
R.H. Lap F_4			3.3	3.9		
L.H. Lap F_3	2.3	3.5	1.8	3.0		
Crotch						

Space Requirements (m)	Forwards Space		Sideways Space	
Head	0.90	0.97	0.68	0.69
Shoulders	0.65	0.73	0.52	0.55
Pelvis	0.37	0.38	0.45	0.44
Hands	1.11	1.18	0.77	0.75
Feet	0.93	0.97	0.60	0.57

Space Availability (m)	Forwards	Sideways
Morris Mini De-Luxe	Not available	Not available
Volkswagen 1600 Superbug	Not available	Not available
Ford Falcon	0.66	0.80

SUMMARY OF RESULTS OF DYNAMIC TESTS ON CHILD RESTRAINT

Restraint Type:- **Adult lap belt with "3 years" dummy**

Test

	Head-on		L. Front Cnr		Left Side	
Collision Aspect	Head-on		L. Front Cnr		Left Side	
Tight or Slack	Tight	Slack	Tight	Slack	Tight	Slack
Test Number	73097	73098				
New Sample?		No				

Sled Deceleration

	Tight	Slack
Change of Velocity (km/h)	39.5	39.1
Peak Deceleration (m/s^2)	174	175
Duration (ms above 10% of Peak)	100	99

Peak Webbing Tensions (kN)

	Tight	Slack
R.H. Shoulder		
L.H. Shoulder		
R.H. Lap	Not measured	
L.H. Lap	1.41	1.80
Crotch		

Space Requirements (m)

	Forwards Space	
Head	0.71	0.76
Shoulders	0.56	0.60
Pelvis	0.27	0.31
Hands	0.89	0.97
Feet	0.78	0.85

Space Availability (m)

Morris Mini De-Luxe	Not available
Volkswagen 1600 Superbug	Not available
Ford Falcon	0.66

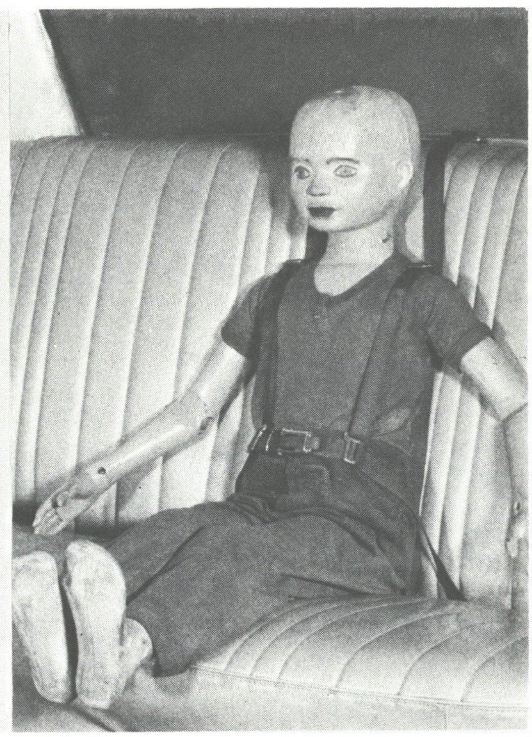
APPENDIX No. 17

CLIPPER-SAFE "TRAINER" AND "PILOT" HARNESSES

Photographs

TRAINER

TARU Negative 428-14



PILOT

TARU Negative 428-20

Description

Trainer

Shoulder harness with encircling waist level strap. Sliding connection at rear to single vertical anchor strap on surface of vehicle seat backrest. The device did not have SAA approval.

Pilot

Shoulder harness with waist level strap. Shoulder straps had sliding connections to two anchor straps in inverted "vee" form on surface of backrest of vehicle seat. Waist strap picked up lower anchorage points of the anchor straps. The device did not have SAA approval

<u>Connection to Car</u>.

Anchoring strap end fittings were bolted to parcel shelf and to vehicle structure below and behind seat backrest.

Length of anchor strap in each type was sufficient to permit its connection to the rear compartment floor of a station wagon or other vehicle which did not have a parcel shelf.

<u>Specified Occupant Range</u>

"Trainer" - no range specified.

"Pilot" - children up to 80 lb mass.

APPRAISAL OF CHILD HARNESSES

Type

Clippa-Safe harnesses.

Comment

The design of these harnesses was such that it was not possible to locate their lap belts on the occupant's pelvis. Both types had a particularly high mounted lap strap, which in the case of the "Trainer" bore against the bottom of the rib cage.

The "Trainer" harness broke in two successive runs and allowed the dummy to be ejected. Examination of high speed cinematographs indicated that, prior to the breakage, the waist strap was tightening onto the dummy in the abdominal area just below the ribs. We are confident in stating that a child wearer would suffer internal injury from the waist strap in real crash conditions.

The "Pilot" harness provided better restraint in that the lap belt did not fully encircle the dummy, but was conventionally anchored. Nevertheless, the belt could not satisfactorily be located on the pelvis in our simulation and therefore still posed a risk of internal injury.

The "Pilot" harness bore the British Standards Institution Kite Mark and was approved to BS3254 - "Children's Restraining Devices". This Standard was superseded during 1973 by BS AU 157:1973. The instruction leaflet for "Pilot" also bore the Note"

> "B.S. 127 for all cars including estate cars and those with fold down seats".

We have been unable to relate this Standard to the harness; BS 127:1930 is a superseded Standard governing circuit breakers; BS AU 127:1966 deals with road vehicle laminated springs. It is possible that the Note is intended to refer to B.S. AU 157.

The "Trainer" harness did not claim to satisfy any Standard. Our sample did not have an instruction leaflet supplied.

Strap length adjustment was quite simple on both harness types. No slip was recorded on the "Pilot" during crash simulation. We were not able to estimate slip on the Trainer as it broke in two consecutive tests.

Both harnesses had buckles at the centre point of the "lap" belt. In the case of the Trainer, the buckle consisted of a slotted metal tongue which was passed through a slot in the mating component, then secured by a strip of ½ inch wide seat belt webbing. The Pilot buckle was a lever type device which we found very difficult to assemble correctly, it being necessary first to align two 1/16 inch thick metal pressings edge to edge, then to thread a ½ inch wide strip of seat belt webbing through a protruding slotted tongue. The buckle of the Pilot appeared to be very prone to inadvertent release.

We considered that there were several reasons why these harnesses would not have met the requirements of AS E46:

(a) It appeared that the "Trainer" was not designed to minimise lateral, vertical or somersaulting movement of its occupant.

(b) Only two anchorage points vertically above each other, were provided by the "Trainer". No horizontal spread of the load was provided, the occupant being liable to crushing by the waist strap.

(c) The webbing of "Pilot" harness was not permanently attached to all fittings.

Further to these points, it would have been necessary to establish that in each case, the device would satisfy the static strength test requirements of AS E46-1970; also that webbing material would comply with the requirements of AS E47-1971.

SUMMARY OF DYNAMIC TEST RESULTS FOR UNAPPROVED CHILD RESTRAINT DEVICE.

Type

Clippa-Safe "Trainer" harness.

Clippa-Safe "Pilot" harness.

Test Procedure

Each harness was tested in a frontal crash simulation. In both cases the Sierra "Sammy" 50 lb, "6 year old", dummy was used. The Pilot harness, from its packaging illustrations, appeared intended for the younger child but could not be satisfactorily adjusted to fit the Sierra "Toddler" tightly. Following a fracture of the harness when used with the "Sammy" dummy, a simulation was carried out with the "Toddler".

Owing to the possibility of fracture of the device, and subsequent damage to instrumentation, no webbing force transducers were fitted to the harness.

Sled deceleration data and space requirements are presented in the table overleaf.

TABLE OF DYNAMIC TEST RESULTS - CLIPPA-SAFE HARNESS

HARNESS TYPE	RUN NUMBER	SLED DECELERATION VELOCITY CHANGE km/h	SLED DECELERATION PEAK DECELERATION m/s^2	DURATION ms *	SPACE REQUIREMENT m.	SPACE AVAILABLE m.	OBSERVATIONS
Trainer	73-237	40.2	173	101	Not Measurable	.66 Ford Falcon .54 Volkswagen Superbug .62 Morris Mini	Anchor strap broke. Dummy ejected
Trainer	73-238	40.3	173	101	Not Measurable		Anchor strap modified to double thickness. Harness connection broke. Dummy partially ejected.
Pilot	73-241	39.3	171	101	Head : .60 Shoulder: .15 Hand : .76 Foot : .88 Pelvis : .05		Dummy restrained, no apparent damage to harness.

* Duration is portion of pulse above 10% of peak deceleration.

APPENDIX NO. 18

MICKLEM 725 LAP BELT

MICKLEM 710 SHOULDER HARNESS

MICKLEM 715 BOOSTER CUSHION

Photograph

TARU Negative 428-11

Description

Two piece harness and cushion which could be used separately or in combination. The 710 shoulder harness required the provision of an adult's lap belt if used without the 725 lap belt. Booster cushion was restrainable by threading lap belt through two loops. The components were not approved by SAA.

Connection to Car

One parcel shelf anchorage for shoulder harness. Lap belt replaced adult lap belt.

Specified Occupant Range

4 to 12 years.

40 to 80 lb mass.

APPRAISAL OF UNAPPROVED HARNESS ASSEMBLY

Type

Micklem 725 lap belt

Micklem 710 shoulder harness

Micklem 715 booster cushion

Comment

The lap belt, shoulder harness and booster cushion were purchased separately. The shoulder harness package bore a note stating that the harness should be used with an adult lap belt or the Micklem 725 lap belt. The lap belt package bore a note that the lap belt could be used with the 710 shoulder harness. The instruction leaflet supplied with each component was common to all. The section applicable to the shoulder harness stated that this item was *"Designed to Comply with Australian Standard AS E46"*. Visually, the shoulder harness and the overall assembly appeared to meet the requirements of AS E46.

We considered that these harness components would have failed to satisfy the requirements of AS E46 for at least the following reasons:

(a) The webbing width was less than that specified for an 80 lb child.

(b) A lap belt to be used alone is not permitted.

Further to these points it would have been necessary to have shown that the assembly could satisfy the requirements of the static loading test specified in AS E46-1970.

In crash simulation all combinations of lap belt, shoulder harness and cushion restrained the dummy. Some submarining was observed on run 73-234 and was considered to be a result of compression of the booster cushion which allowed the dummy's 'pelvis' to drop beneath the lap belt.

Adjustment of both the lap belt and shoulder harness proved to be quite easy, the adjusters being similar to those used on the SAA-approved Micklem 694 child seat. No slip was observed in the adjusters except in the "lap belt only" run (73-236) where 14 mm slip was measured at the buckle adjuster.

During those runs in which it was employed, the Micklem booster cushion remained in position with no visible tendency to eject. No damage was noted at the cushion's securing loops, though these were quite light and we were unable to state whether they would similarly resist day to day wear and abuse. Of most concern was the softness of the filling material, this being such that in normal use it supported the child but during the crash deceleration it compressed under the vertical component of the dummy's decelerating force. With a full harness, this compression permitted submarining to occur; with lap belt only, there was an increase in the forward excursion of the dummy due to its radial motion about the lap belt anchorage point.

SUMMARY OF DYNAMIC TEST RESULTS FOR UNAPPROVED CHILD RESTRAINT DEVICE

Type: Micklem 725 lap belt
Micklem 710 shoulder harness
Micklem 715 booster cushion

Test Procedure

The lap belt, shoulder harness and booster cushion were examined in frontal crash simulations in the following combinations:

(a) Lap belt only, Sierra "Sammy" dummy.

(b) Lap belt with booster cushion, Sierra "Toddler" dummy.

(c) Lap belt and shoulder harness, Sierra "Sammy" dummy.

(d) Lap belt, shoulder harness and booster cushion with Sierra "Toddler" dummy.

(e) Shoulder harness plus adult lap belt, Sierra "Sammy" dummy.

In each case the harness was tightly adjusted.

The harness had not undergone the static strength test of AS E46 and it was not known whether it would survive the dynamic test without failure. Accordingly, no webbing force transducers were fitted.

Sled deceleration data and space requirements for the configurations tested are presented in the table overleaf.

TABLE OF DYNAMIC TEST RESULTS - UNAPPROVED MICKLEM HARNESS COMBINATIONS

CONFIGURATION	RUN NUMBER	SLED DECELERATION VELOCITY CHANGE km/h	PEAK DECELERATION m/s^2	DURATION ms *	SPACE REQUIREMENTS m.	SPACE AVAILABLE m.	OBSERVATIONS
Lap belt only Sierra "Sammy"	73-236	39.8	171	101	Head : .84 Shoulder: .56 Hand :1.01 Foot : .77 Pelvis : .22	.62 Morris Mini .54 Volkswagen Superbug .66 Ford Falcon	Dummy restrained but head hit knees. No apparent damage to belt.
Lap belt plus Booster cushion Sierra "Toddler"	73-235	40.1	175	100	Head : .73 Shoulder: .57 Hand : .89 Foot : .80 Pelvis : .24		Dummy restrained. No apparent damage to belt. Dummy arcs forward on lap belt until cushion fully compressed.
Lap belt plus shoulder harness Sierra "Sammy"	73-233	39.9	169	103	Head : .34 Shoulder: .05 Hand : .56 Foot : .83 Pelvis : .12		Dummy restrained. No apparent damage to harness.
Lap belt plus shoulder harness plus booster cushion Sierra "Toddler	73-234	40.3	171	101	Head : .25 Shoulder: .03 Hand : .43 Foot : .73 Pelvis : .18		Dummy restrained. Some submarining evident owing to compression of cushion. No apparent damage to harness.
Shoulder harness plus adult lap belt Sierra "Sammy"	73-232	40.0	169	102	Head : .33 Shoulder: .06 Hand : .55 Foot : .74 Pelvis : .10		Dummy restrained. No apparent damage to harness

* Duration is portion of pulse above 10% of peak deceleration.

PART V

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REFERENCES

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