The History of SIMRET

SIMRET (or Safety In Mines RETardometer) was originally developed in the 1980's by the Special Instruments and Techniques Section of the Safety in Mines Research Establishment (SMRE) – part of the Research Division of the UK Health and Safety Executive. The development was sponsored by the Mines and Quarries Inspectorate who required an instrument to test haulage systems in deep coal mines.

It quickly became apparent that the instrument would also be of great benefit in testing the braking performance of heavy surface machines and dumper trucks. Whilst other brake testers were available, they were first and foremost designed for testing road going vehicles and gave unreliable results except on level and smooth surfaced roads.

The original SIMRET design and know-how was licensed to Turnkey Instruments Ltd for commercial exploitation. Turnkey Instruments Ltd are now the sole licensee for SIMRET technology. A small royalty is paid to HSE on every sale to fund further safety research.

On the following pages is the original report on SIMRET produced by the Mines and Quarries Inspectorate of the UK Health and Safety Executive.

Over the years since then Turnkey has improved the instrument in numerous ways to address the shortcomings highlighted with the original prototypes. Features like one man operation, automatic start and stop, brake delay times, printouts including graphs, PC interface, and so on are now standard features on the latest SIMRET 3000 instrument.

HEALTH and SAFETY EXECUTIVE

TESTING OF DUMP TRUCK BRAKES

During the period April-December 1984 a project was undertaken to determine the effectiveness of service brakes of a wide range of dump trucks used at quarries in the North Eastern District. A prototype battery powered electronic retardometer developed by the Safety in Mines Research Establishment (SMRE) and known as the SIMRET retardometer was used.

A total of 199 dump trucks involving 38 models from 12 manufacturers were tested. This total includes some vehicles which were re-tested after rectification of discovered defects. The SIMRET retardometer was also used to test fuel and water bowsers plus a small number of quarry personnel vehicles. Vehicle emergency brakes, parking brakes and retarders were often tested with the instrument, but enquiries had first to be made to ensure dynamic testing would not damage these brakes.

SIMRET RETARDOMETER

The portable battery powered electronic retardometer was developed for testing underground haulage systems but has yet to be flameproofed. Since the instrument has to be started and stopped manually, it is necessary for the testing engineer to travel on the vehicle being tested, a difficult task on vehicles with small cabs and only one seat. SMRE engineers state that 10 retardation measurements per second are taken throughout a SIMRET test and stored in the instrument's memory. A retardation average can readily be obtained on the digital display. When preparing the retardometer it is necessary to park the vehicle under test on a level road before levelling the instrument on a firm surface in the cab.

BRAKE TEST PROCEDURE

When the project commenced it was intended to compare dump truck brakes when trucks were empty, but it was discovered that the better braked vehicles often skidded or bounced on un-surfaced site roads. This resulted in a wide variation of empty truck retardations. Therefore, for the purposes of the project, braking standards are compared for loaded trucks. Pay loads for identical vehicles obviously vary due to loading methods and material carried, but variation in vehicle brake efficiencies appeared to be far greater than differences in loads.

The SIMRET retardometer was used to measure vehicle retardation when brakes were fully effective. Drivers were instructed to drive at normal maximum speed before applying the service brake. Only when the brake time delay time had expired and full retardation was felt was the retardometer recording started. The retardometer was switched off immediately before the vehicle came to rest.

The art of operating the retardometer improves with practice. The longer the braking period the narrower is the band of retardation results, but even at slow speeds with test periods of about one second it was, with experience, possible to obtain reasonably repeatable results.

With only a few exceptions, tests were carried out on un-surfaced site roads. Were possible smooth, level roads were used but, except for a few large opencast sites, these rarely existed and tests were often on gradients. The design of the SIMRET retardometer automatically compensates for gradients during the brake testing period and the recorded measurement is the retardation converted to a level road condition.

OTHER BRAKE TESTING METHODS

At three quarries Tapley inertia type retardometers were also used during brake testing and their measurements compared with those recorded by SIMRET. Tapley results varied widely and were severely affected by the unevenness of the road and by the final jerk at the instant the braked vehicle came to rest. The SIMRET recorded consistent retardations.

An inertia type retardometer may be reasonably accurate if tests are conducted on smooth surfaced roads. In such tests on roads on the premises of a dump truck manufacturer a Bowmonk inertia type retardometer gave readings comparable with the SIMRET.

The International Standards Organisation's ISO 3450:1975 "Earth Moving Machinery and Wheeled Machines - Performance and Test Procedures for Braking Systems" specifies a brake stopping distance formula, a method similar to that adopted in Britain for the testing of underground mine locomotives. For such testing it is necessary to have a prepared test road of known gradient and the speed of the vehicle is required to be measured to an accuracy of ± 3 per cent. This test procedure is suitable for testing by vehicle manufacturers and may be practicable at large, long life opencast sites, but is unlikely to be feasible at other quarries.

Enquiries were made regarding brake testing methods adopted for heavy road goods vehicle by Local Authority Vehicle examiners. The general practice appears to be to order any suspect vehicle to a Ministry of Transport Testing Station for the brakes to be tested by a dynamometer, a method by which maximum developed brake force is measured using a powered roller to drive each braked wheel in turn. Tapley inertia retardometers are sometimes used, but it would seem that vehicle examiners are sceptical as to the accuracy of the instrument.

Vehicles operating on public roads are required to conform to the Vehicle Construction and Use Regulations which specify minimum brake efficiencies to be developed for different classes of vehicles. There is no similar legislation in Britain for off highway vehicle brakes.

PROJECT TEST RESULTS AND OBSERVATIONS

The appended test results show the types of loaded dump trucks, together with the minimum, maximum and average retardation for each model recorded by the SIMRET retardometer. For comparison purposes the calculated average retardation required by ISO 3450:1975 have been included with the test results. These are 22 per cent g for trucks with a gross weight of up to 45 tonnes and 16 per cent g for those above 45 tonnes, these figures have been superseded by ISO 3450:1996 (see SIMRET makes Heavy Vehicle Brake Testing easy issue 2). SIMRET recorded retardations, which are of developed braking, should always be higher than the ISO calculated average retardation, which is for the whole test period including the initial brake delay time.

Twelve dump trucks (6 per cent of the total) were discovered to develop brake efforts of only 12 per cent g or less. The majority of these were re-tested at a later date after

defects had been rectified and the brakes found to have been vastly improved. In the later stages of the project, when possible brake efficiencies of many types of dump truck had been determined, vehicle brakes which fail to meet the calculated ISO average retardation were inspected in some detail and defects usually discovered and rectified simply.

None of the quarries visited operated any system for dynamic testing of dump truck brakes. One opencast site used a Tapley meter for testing Landrovers and other light site vehicles on a concrete road, but safety precluded the testing of heavy earth moving machinery on the same road. On the concrete road the Tapley meter gave an indication of brake effectiveness.

A number of mechanics tested brakes of dump trucks equipped with hydraulic torque converters by engaging first or second gear and increasing engine revs until the wheels moved through the applied brakes or maximum engine power was held. Caterpillar is the only manufacturer known to describe such a static brake holding test in their maintenance literature, but this requires an effective engine rev counter, an instrument frequently neglected.

Static brake holding tests were frequently conducted during the project. They were by no means accurate but proved a useful method for revealing vehicles with seriously defective brakes. One opencast site has instructed all drivers to conduct static brake holding tests of service, emergency and parking brakes during each shift.

The most frequent brake defect discovered was the need for brakes to be properly adjusted. The Terex R range of dump trucks appear to loose considerable brake effectiveness if they are not well adjusted, a task which takes no more than ten minutes per vehicle. Most quarries had scheduled vehicle maintenance, but in practice brakes were frequently only adjusted when the driver complained. Surprisingly, drivers often accepted poor brakes, but it could be that they had never had good brakes or had not observed a gradual deterioration.

Serious brake air leaks were often responsible for a dramatic loss of brake efficiency. Some leaks could be heard above the engine noise, but all were audible if service brakes were applied after the engine had been stopped, a test not carried out routinely at any quarry. Brake rubber diaphragms on some models of dump trucks appeared to be prone to burst in service.

Examination of two Terex dump trucks after unsatisfactory retardation measurements revealed brake cylinders torn from welding attaching them to their supporting plates. After severe criticism of the brakes of an old Euclid R25, a mechanic subsequently found broken piston rods in the rear brake cylinders, a defect which was not visually obvious until the brakes were dismantled. Brakes on two dump trucks required relining before satisfactory retardations were achieved. A cracked brake drum was discovered on a dump truck after retardation tests had shown the brakes to be unsafe.

The SIMRET retardometer was reliable throughout the project, the only instrument failure was due to the loosening of an internal assembly nut which was rectified on site. The battery had to be re-charged after each day's use but was not changed.

CONCLUSIONS

1. The SIMRET retardometer is a practical instrument for quick on-site testing of vehicle brakes. Most tests can be conducted while dump trucks are employed in their normal work.

2. The main operating problems with the SIMRET retardometer are:

   (a) It has to be levelled on a firm surface in the driver's cab. This can be impossible in cabs designed only for a driver and prevented the brake testing project being extended to motor scrapers, which are frequently suspected of having defective brakes.

   (b) The testing engineer has to sense when the applied vehicles brakes have developed maximum brake effort, although with experience test results were surprisingly consistent for each vehicle.

3. No quarry had any formal dynamic method for testing dump truck brakes. Tapley meters are unreliable except for smooth surfaced roads. Many of the larger quarry companies would purchase a SIMRET retardometer if they were available for sale.

4. The majority of quarries have dump truck maintenance schemes but many had relied on drivers complaining before brakes were adjusted. Drivers' lack of knowledge of their vehicles and their frequent failure to be aware of seriously defective brakes is alarming.

5. Brake efficiencies measured were not found to be necessarily dependent on the gross weight of the dump truck. Age of vehicle manufacture was important and their was ample evidence that manufacturers had gradually improved brake design. Modern models equipped with oil immersed multi-disc rear brakes gave very consistent retardations and required little brake maintenance.

6. Of the 199 dump trucks tested, 6 per cent had brakes which developed retardations of 12 per cent g or less. A total of 19 per cent of the dump trucks developed retardations less than the required minimum retardation of ISO 3450:1975 which includes the brake delay period.

7. Defects causing serious reduction of brake efficiency were:

   (a) Lack of brake adjustment - this was the main cause.

   (b) Serious brake air leaks sometimes associated with burst rubber brake diaphragms.

   (c) Two cases where welding had failed on front brake cylinder mountings - a Terex R25 and a Terex R35.

   (d) Worn and oil contaminated brake linings.

8. The vast majority of dump trucks are designed to have effective brakes if properly maintained. The one exception appears to be the Terex R35 truck and none of the 12 tested developed a retardation above 18 per cent g, a level only attained after brakes had been relined and correctly adjusted. Terex R35s are no longer manufactured and all tested were all made prior to the introduction of ISO 3450:1975.

9. Local Authority Vehicle Examiners are only provided with inertia type retardometers for highway testing of goods vehicles, but suspect vehicles are ordered to a Ministry of Transport Test Station for dynamometer brake testing.

RECOMMENDATIONS

1. Each mines and Quarries Inspectorate District should be provided with a SIMRET retardometer. This should preferably be flameproofed to allow underground testing of haulage systems.

2. Consideration should be given to developing the SIMRET retardometer to give a graphical display of the total brake period with facilities to record delay times and retardations at any part of the braking period.

3. If possible the SIMRET retardometer should be made automatic to enable it to be attached to vehicles with cabs too small to carry a testing engineer.

4. HM Inspectors of Mines and Quarries should adopt common minimum brake standards for dump trucks which it is suggested should be:

   (a) Any loaded dump truck which produces a developed retardation of less than 12 per cent g is stopped from further use until braking is improved, irrespective of site conditions or speed.

   (b) Any loaded dump truck which produces a developed retardation of less than 16 per cent g should be stopped from further use until braking is improved, unless the site is level and the vehicle speed does not exceed 10 mph.

   (c) The average dump truck SIMRET retardations calculate in the appended results should be used as a guide for braking standards that can be obtained by basic maintenance. Inspectors should request early improvement if a dump truck's developed braking is considerably below the project quoted SIMRET average. The number of tests carried out for any model of dump truck naturally affects the quoted average retardation.

5. In order to extend the potential market of the SIMRET retardometer, the Safety in Mines Research Establishment should consider arranging demonstrations of the instrument. Invited organisations should include HM Factory Inspectorate, Ministry of Transport, and large civil and quarrying companies. Wherever possible demonstrations of brake testing should be with a large vehicle with room for the driver, demonstrator and interested person, but if necessary a private car could be used.

6. The marketability of the SIMRET retardometer will depend on the guaranteed accuracy of the instrument. A specified method of conducting tests will be necessary if measured retardations are to be quoted in courts and at inquests or if Prohibition and Improvement Notices are to be issued.

SUMMARY OF DUMP TRUCK RETARDATIONS

Number of dump trucks tested	199
Number of dump trucks with retardations not exceeding 12 per cent g	12
Number of dump trucks with retardations less than 16 per cent g	22
Number of dump trucks with retardations less than that calculated from ISO 3450:1975	37

End of MQI Report