Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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GENERAL INFORMATION

ARTICLES

Foreword

Osamu MURATA
Director, Marketing and Business Development Division

The Business Promotion Division of Railway Technical Research Institute (RTRI) promotes a wide range of research projects for the government, the Japan Railway Construction, Transport and Technology Agency, railway operators and other organizations. These research projects are significant especially because: (1) the results of RTRI's research and the know-how gained from it benefit society; (2) the research leads to the acquirement of basic information on client needs and technical data that can be used to formulate new research and development goals; and (3) the projects provide economic benefits to RTRI itself.

We recently installed within the Business Promotion Division two new sections - one in charge of promoting the maintenance of railway structures, the other in charge of examining railway use. These two new sections will keep communications open between clients such as railway operators and the research units within RTRI. Since the maintenance and management of railway structures is extremely important to railway operators, the section in charge of promoting railway structure maintenance has been equipped to provide them with as much support as possible. As of April 2006, this section has a chief and three staff members. They are meeting with railway operators to discuss what RTRI can do to help them maintain and manage their railway structures.

In addition to promoting the maintenance and management of railway structures, the Business Promotion Division is keen to carry out other activities that will be helpful to its many clients.

村田 修

A Sample of Products Developed by Railway Technical Research Institute

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Railway Technical Research Institute (RTRI) conducts tests and research for companies and other organizations, using know-how that it has accumulated through its extensive R&D activities. In this way, RTRI responds to diverse needs of the railway industry and the traveling public, both at home and abroad.

The many and varied R&D projects commissioned to RTRI include testing, studies, design and engineering. We also offer lectures and advice on a wide range of rail technology issues.

Ten major products developed by RTRI are outlined below.

1. Products for vehicles

- Cerajet (an adhesion improvement material jetting device): This device is used to improve the adhesion coefficient by jetting ceramic or silica sand particles between the wheel and the rail. Because of the high jet speed and good response, the device can be interlocked with slide/slip signals and emergency brake commands. It can be used during both low and high speed operations (Fig. 1).
- Servo-cylinder for tilting car: This compact device combines a cylinder, servo-valve and displacement sensor. It controls the tilt of a tilting car.
- Semi-active suspension system for railway vehicles: This system significantly reduces lateral vibrations of a carbody above the bogie springs, making it possible to increase running speed and improve riding comfort.
- Simple vibration and riding comfort measurement device: This compact, low-cost system measures vehicle vibrations easily, even during commercial runs. Simple software for analyzing vehicle vibration and riding comfort levels has also been developed for the device.

2. Products for signal, communication and electric systems

- Computer and Microwave Balise-Aided Train control system (COMBAT): This system detects a train with a non-contact, point-detection method using microwaves. It is equal or superior to conventional track circuitry in terms of safety and detection performance (Fig. 2).
- Catenaries/pantograph system motion simulator: This simulator facilitates complicated calculations to accurately analyze the design and deformation of overhead contact wire structure, the motion of catenary/pantograph systems, etc., using a personal computer.
- POWER DIAGRAM: This simulator permits ascertaining the ever-changing load factors of each train in an operating schedule within an entire track section. It can be used to calculate suitable substation capacity, pantograph point voltage, etc.

3. Products for infrastructure

- Ladder track: This ladder-shaped track system is composed of a pair of rails on longitudinal pretension concrete beams that are fastened together with lateral steel pipes. We have developed two types of ladder tracks: a ballasted ladder track for track laid on ballast, and a floating ladder track for track not laid on ballast (Fig. 3).
- Micro LABOCS (track maintenance and management database system): The database contains track inspection data, measurement data obtained during train operations, track diagrams, etc. The data can be analyzed and processed as needed.
- IMPACT-III (bridge substructure soundness evaluation system): RTRI has established an impact and vibration test method to accurately determine the soundness of bridge substructures and elevated bridges. Our bridge substructure soundness evaluation system "IMPACT" effectively supports test functions. IMPACT-III is the latest IMPACT edition.

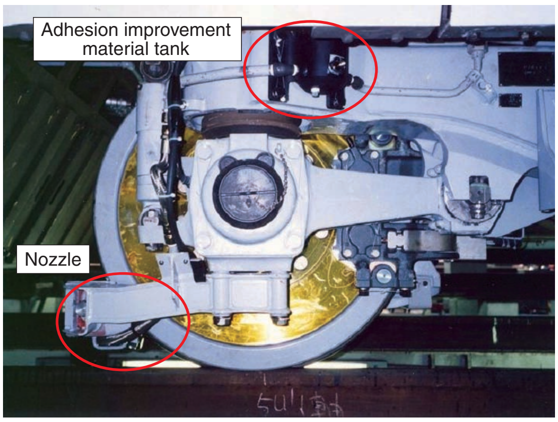

Figure 1. Installation of Cerajet

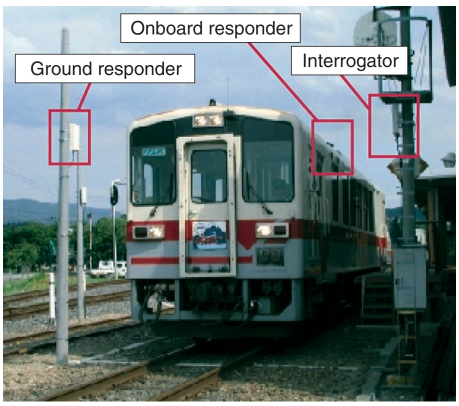

Figure 2. COMBAT

Figure 3. Floating ladder track

A New Algorithm for Train Rescheduling Using Rescheduling Patterns

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If train services are disrupted, they can be brought back to normal in a number of ways, including canceling train runs, turning trains back, altering departure sequence, or using different tracks. All such schedule modifications are called train rescheduling. Train rescheduling plans are prepared by train dispatchers.

We recently developed an algorithm for computerized train rescheduling planning, and tested it on an actual track section. The tests confirmed that our algorithm can be used for practical train rescheduling.

At present, train dispatchers prepare train rescheduling plans on the basis of experience and intuition. However, train rescheduling involves a number of difficulties, including:

- The rescheduling of many trains may not be possible within the short period of time permitted.
- Judgment criteria are not always the same—they depend to a considerable extent on existing circumstances, which vary from case to case.
- Some considerations are difficult to quantify.

Computer-based support for train rescheduling would greatly lighten the burden placed on train dispatchers.

Since train rescheduling is an extensive operation involving different departments within the railway company, it is necessary to clearly identify each issue. For the general configuration of our train rescheduling system, we devised the framework shown in Fig. 1. The framework divides the entire system into subsystems (the figure also represents, in chart form, the relationships between subsystems). Our new algorithm is based on this framework.

Over the last few years, railway operators in Japan are increasingly using train rescheduling patterns. These patterns incorporate rescheduling techniques which are customarily adopted by some train dispatchers, and are expressed in such a way that they can be understood by other train dispatchers as well. Since train rescheduling patterns incorporate train dispatchers' knowledge (which includes knowledge of the railway operator's management policy, recommended counter-measures when dealing with unexpected phenomena, and conditions unique to specific locations), the patterns can be used to prepare a practical train rescheduling plan.

The algorithm we developed is composed of Rescheduling Pattern Description Language R (to permit the computer system to learn train rescheduling patterns), and R-Interpreter (which interprets and applies the train rescheduling patterns). R-Interpreter operations are shown in Fig. 2. R-Interpreter allows for speedy preparation of a train rescheduling plan that reflects the knowledge of train dispatchers.

However, simply applying train rescheduling patterns is not enough to formulate a practical rescheduling plan. This is because so many different situations call for train rescheduling that relevant train rescheduling patterns are not always available for a specific situation. Indeed, there are trains for which no existing train rescheduling patterns are applicable. We therefore adopted a two-stage system configuration: (i) train rescheduling patterns are used to create a general image of the train rescheduling plan (indicating decisions regarding major services to be cancelled, and timetable alterations to accommodate the cancellations), and (ii) a scheduling algorithm is used to decide matters for which the rescheduling patterns cannot be applied. This has made it possible for a computerized system to automatically prepare a practical train rescheduling plan. By conducting experiments using actual train schedule data, we confirmed that our algorithm is effective (see Fig. 3).

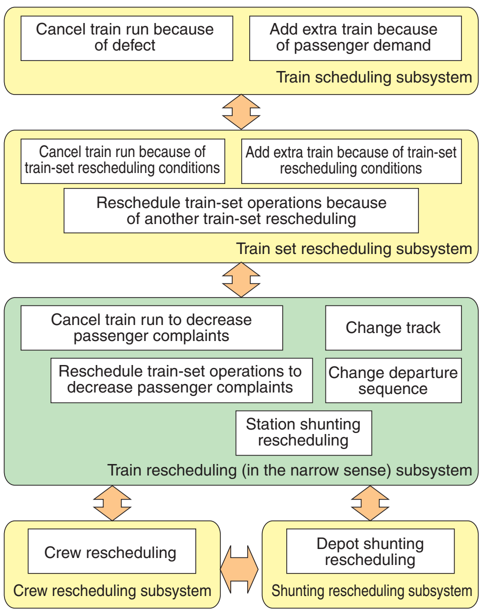

Figure 1. Framework of train-rescheduling system

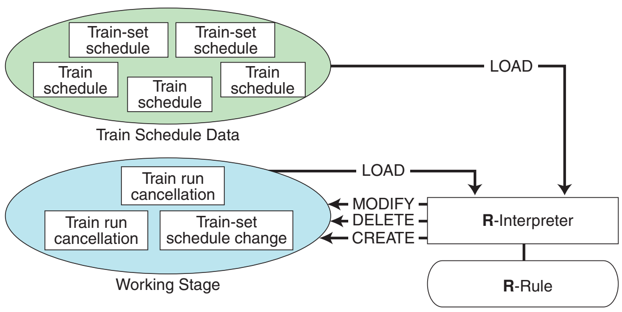

Figure 2. Operations of R-interpreter

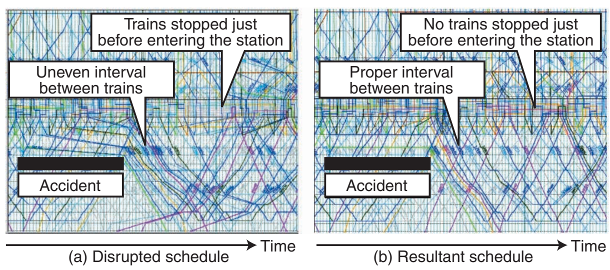

Figure 3. Disrupted schedule and Resultant schedule

Evaluation of Train Rescheduling Alternatives Using Station Service Indices

Taketoshi KUNIMATSU
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During the disruption of train services, a series of timetable alterations must be made to return services to normal. This series of corrective actions is called train rescheduling. To evaluate train rescheduling alternatives, a number of indices have been proposed, such as the total time of train delays, and the number of trains canceled. However, such indices deal only with matters from an overall operational standpoint, and do not reflect the standpoint of individual passengers suffering the inconvenience of the service disruption. In addition, evaluation results cannot be understood instantly.

This paper proposes the use of individual station service indices to evaluate train rescheduling alternatives. Each station service index expresses, in terms of actual travel speed, the extent of service that passengers departing from the station can receive on average, under a specific rescheduling timetable. When determining these individual station service indices, we added a component reflecting passenger dissatisfaction with the increase in congestion.

Individual station service indices are calculated as follows.

(1) Using the train rescheduling timetable and automatic ticket inspection machine data, infer the trains that each passenger takes from their departure station toward their intended arrival station, then calculate the actual time required for their travel, including wait time.

(2) From the data on the number of passengers in each train, estimate each passenger's dissatisfaction quotient with regard to crowded conditions, and expressed this quotient as time. Add this time to the actual time required for travel.

(3) Divide the distance from the departure station to the intended arrival station by the sum of (1) and (2), to obtain the effective speed (perceptible travel speed) for each passenger.

(4) Calculate the average effective speeds for each of the departure stations and assume it as the station service index for that departure station.

Using these station service indices, we evaluated an actual train rescheduling plan (Rescheduling Plan X, Fig. 2) that was implemented in a quadruple-track section (track layout shown in Fig. 1), and an operations rescheduling alternative (Rescheduling Alternative Y, Fig. 3) that was based on a different concept. The train rescheduling was required after a traffic accident involving injury occurred at Station D, forcing the operation of up and down trains on the inside tracks to stop for about 30 minutes, beginning at 5:26 p.m. In this section, express trains normally run on the outside tracks, while rapid and local trains run on the inside tracks. Under Rescheduling Plan X, the route for rapid trains indicated by the brown lines in Fig. 2 was changed from the inside to the outside track. Rapid trains ordinarily stop at Station C. However, in Rescheduling Plan X, rapid trains do not stop at the station because the station has no platform for the outside tracks. On the other hand, under Rescheduling Alternative Y, rapid trains continue running on the inside tracks, with no change in track. In this case, rapid trains could stop at Station C, but the problem of a delay of the rapid train arises. The calculated station service indices for these two cases are shown in Fig. 4.

Under Rescheduling Plan X, the station service index for Station F, where express trains do not stop, is higher than under Rescheduling Alternative Y. On the other hand, station service indices at stations A and B are higher under Rescheduling Alternative Y than under Rescheduling Plan X. This is because with Rescheduling Alternative Y, although two up rapid trains would be forced to stop at Station F for a long time, express trains running on the outside tracks would not be delayed. Thus, use of station service indices makes it possible to easily ascertain the convenience quotient of passengers departing from each station.

Our future tasks with regard to station service indices include considering passenger dissatisfaction levels for matters other than the longer travel time and greater vehicular congestion (e.g., their need for extra transfers), and improving the accuracy of models representing passenger behavior during service disruption.

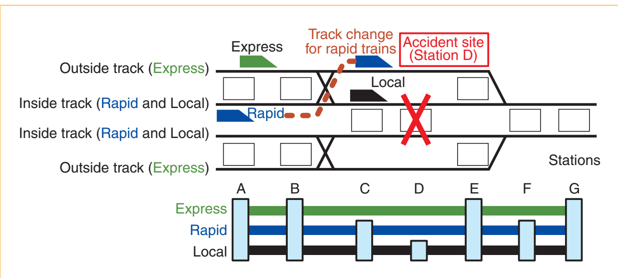

Figure 1. Track layout of affected section

Figure 2. Train Rescheduling Plan X (plan actually implemented, with track change)

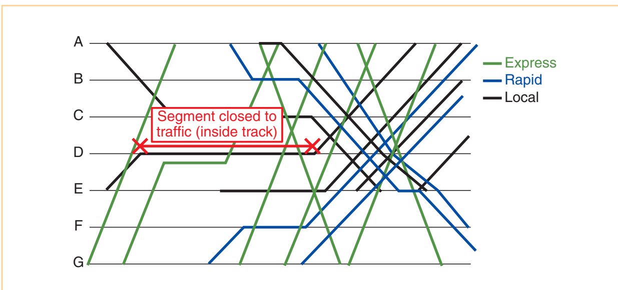

Figure 3. Train Rescheduling Alternative Y (modified plan, without track change)

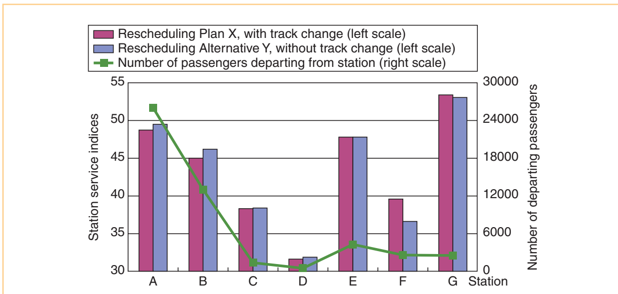

Figure 4. Calculated station service indices

Development of a New Pantograph Contact Strip for Ultrahigh-Speed Operations

Hiroshi TSUCHIYA
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With Shinkansen trains traveling at even higher speeds, it is expected that wear rates of pantograph contact strip will increase significantly, because of such factors as the stronger collecting current and the greater number of arc discharge generated during contact loss. Any development of a new contact strip material for effective use at an ultrahigh-speed (speeds above 300 km/h) would have to achieve better heat resistance and lubricating capability by improving iron-based sintered alloy which is used in high speed trains.

Our objective is to develop a new contact strip material offering more effective performance at ultrahigh-speed. Wear characteristics of a new contact strip material which contains tungsten were compared with those of the unleaded sintered alloy contact strip that had already been developed. A high-speed wear tester for current-collecting materials, which permits evaluation of wear behavior under simulated ultrahigh-speed conditions (exceeding 300 km/h), was used to evaluate the wear characteristics of each contact strip material.

By conducting sliding wear tests at a speed of 400 km/h, using the high-speed wear tester for current-collecting materials (see Fig. 1) under electric current, it was confirmed that the addition of a tungsten-based material as a hard, heat-resistant metallic component improved arc discharge resistance significantly, and made it possible to achieve wear resistance superior to that of a conventional material (see Fig. 2).

The developing material is higher in density than that of conventional material because tungsten is heavy, so the pantograph incorporating the developing material would be heavier than one with a conventional material. In addition, a contact strip incorporating the developing material would cost more, because tungsten is expensive. We are planning to develop better contact strip materials which contain optimal tungsten volume to maintain the excellent wear characteristics, and reduce the cost and the weight.

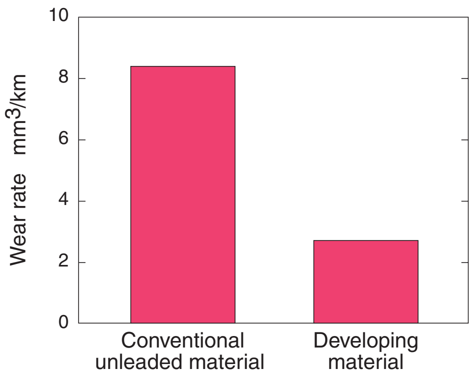
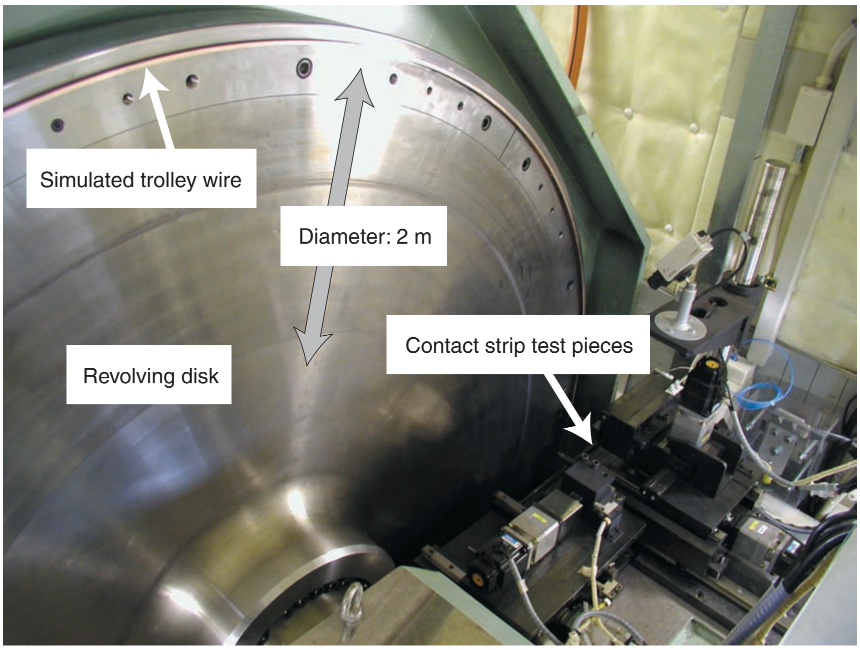


Figure 2. Comparison of wear resistance at 400 km/h



Principal test conditions

(1) Speeds:
300 km/h, 400 km/h

(2) Current:
50 A/strip

(3) Contact loss rate:
Approx. 30% to 70%
(measured by voltage drop)

(4) Applied force:
49N

Figure 1. High-speed wear tester for current-collecting materials, and principal test conditions

Axle-Box Rotary Shaft Lip Seal for High-Speed Shinkansen Cars

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When the speed of Shinkansen cars is increased to a range of 350-400 km/h, there is a concern that oil leakage from the axle-box rotary shaft lip seal could increase to the extent that it would be difficult to ensure normal lubricating conditions for the axle bearings, because the higher shaft rotational speeds make sliding conditions severe. We therefore developed a new axle-box rotary shaft lip seal for high-speed Shinkansen cars with the ability to withstand exceptionally severe sliding conditions.

The results of bench tests of axle-box rotary shaft lip seals are shown in Fig. 1. Conventional seals 1 and 2 both showed oil drips under high-speed conditions, indicating that neither is suitable for high-speed Shinkansen cars (see Fig. 1 (a)). An examination of the seals and oil throwers after the tests showed that lip radial loads were normal, and hardness measurements indicated that the degree of rubber deterioration was small. The amount of wear on the parts of the oil throwers in contact with the lip was also negligible. However, an observation of the lip contact surface of each of the conventional seals revealed outbreaks of flaking on almost the entire circumference (see Fig. 1 (b)). In particular, the outbreaks of flaking on the two conventional seals were more conspicuous under high-speed conditions than under current speed conditions. The outbreaks of flaking of conventional seal 1 were more conspicuous than those of conventional seal 2. It was considered that those outbreaks of flaking were caused by an increase in shear force and contact surface pressure, due chiefly to increases in slip speed and pressure changes. From these facts, it was determined that the oil leakage under high-speed conditions was largely due to the outbreaks of flaking.

Therefore, for the new lip seal for high-speed Shinkansen cars, we adopted fluoroelastomer, which is superior to acrylic rubber in terms of durability and physical strength. We also changed the rubber material filler to restrain early-stage outbreaks of flaking caused by an increase in shaft rotational speed. Furthermore, in order to restrict any change in lip position caused by pressure changes that occur, for example, when the train passes through a tunnel, the rigidity was improved by changing the size and shape. A photo of the test-manufactured lip seal is shown in Fig. 2, and its cross section is shown in Fig. 3.

Our test-manufactured lip seal maintained the original sealing performance with no oil oozing even after the shaft was turned with the number of rotations equivalent to a vehicle running distance of 750,000 km (see Fig. 1 (a)). An examination of the lip seal and oil thrower after the tests showed no problem with the lip radial load, the rubber hardness or the oil thrower. An observation of the lip contact surface showed that the surface condition was satisfactory with few outbreaks of flaking (see Fig. 1 (b)). From these results, it was confirmed that our test-manufactured lip seal has sufficient durability even under high-speed conditions. Because of its satisfactory performance, we consider it suitable as an axle-box rotary shaft lip seal for high-speed Shinkansen cars.

Test-manufactured lip seal: Fluoroelastomer
Conventional seal 1: Acrylic rubber
Conventional seal 2: Fluoroelastomer

Test conditions

	Rotational speed	Maximum pressure (pressure change)*
High-speed conditions	2700min^{-1} (equivalent to 400 km/h)	0.022MPa
Current speed conditions	1890min^{-1} (equivalent to 280 km/h)	0.011MPa

* Pressure was applied to the sealing side periodically.

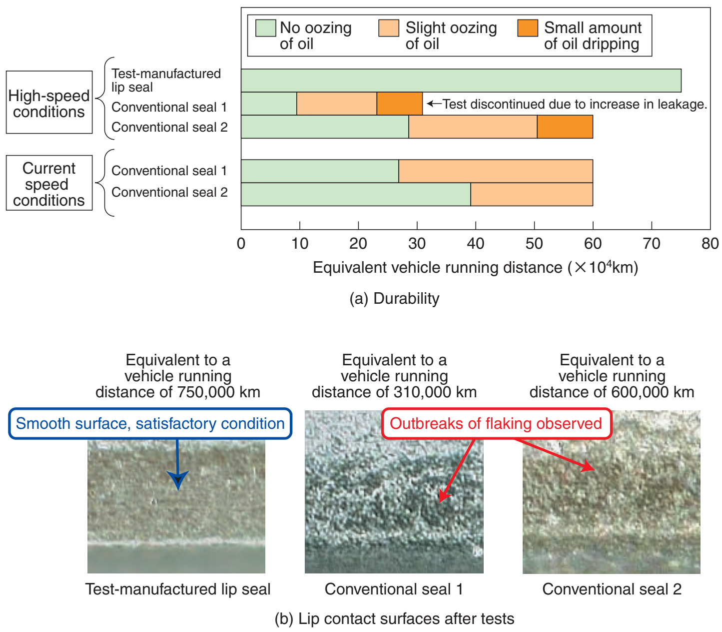

Figure 1. Results of bench tests of axle-box rotary shaft lip seals

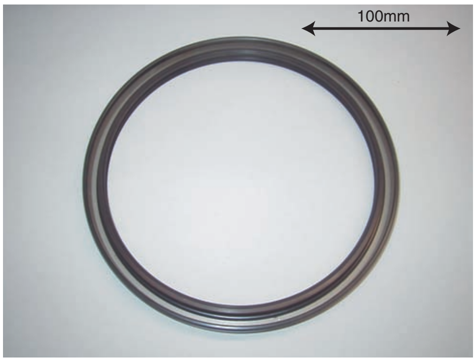

Figure 2. Test-manufactured lip seal

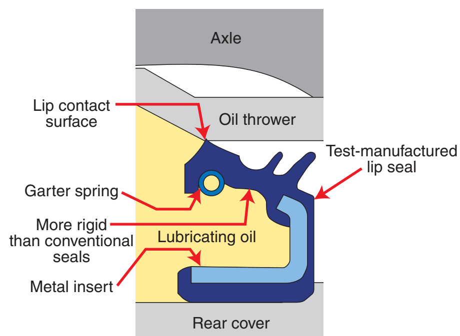

Figure 3. Cross section of test-manufactured lip seal