

DISCUSSION OF PAPERS ON GEAR OILS

MR. D. F. MILLER¹ (*presented in written form*).—Certainly the authors of these papers are to be commended for their efforts in describing an aspect of modern car lubrication that is very complex and difficult to resolve. The nature of these papers attest to the complexity of the current situation.

The paper by A. Towle on the European viewpoint describes how complicated the subject can become when equipment manufacturers do not attempt to seek some standardization of field requirements, although activity in the standardized testing schedules for all vehicles as described by Mr. Towle appears encouraging. This same approach seems worthy of consideration in the United States to resolve some of the present problems. Activity toward this end is now in progress by both ASTM and CRC. These groups should consider the possibility of obtaining a standardized technique (or techniques) which can be run in any piece of applicable equipment.

The European viewpoint, as discussed, appears to be principally that of the equipment manufacturers. One can imagine what the lubricant suppliers' viewpoint might be under these circumstances, but it would be of interest to know how the problem of satisfying the multiplicity of requirements is being handled by the service industry. The difficulties involved become quickly evident when one attempts to prepare service recommendations for United

States cars built for export, or to "Americanize" foreign cars imported to this country. One also wonders about the car owner's reaction and his ability to comply with the specified selection of service materials. Perhaps Mr. Towle can briefly comment on the way in which oil marketers handle the problems of supply and identification and describe what car owners' typical practices may be.

In his Table VI, Mr. Towle shows the results of CRC L-42 tests which rate two oils as CRC 5-90 and 8-90. The L-42 technique was developed to discriminate between oils at 10 or higher and those which are below 10. Using the present technique it is impossible to rate oils at 5 or 8. Perhaps Mr. Towle will explain his method of rating these oils using the L-42 technique. A long-range planning group of CRC gear committee members recently decided that new techniques should be developed to define the lower levels of scoring protection, just as Mr. Towle has attempted to do with the L-42 technique.

The Ford paper by R. F. Gasvoda demonstrates that United States manufacturers also have a very serious attitude regarding the type and quality of rear axle lubricants, and that they recognize the practice and desire of the American car owner to avoid the inconvenience of periodic oil changes.

It is interesting to note that, with only minor exceptions, the tests developed by Ford for use in evaluation of a new lubricant involve an axle assembly.

¹ Chrysler Corp., Detroit, Mich.

The final judgment, despite an impressive list of tests, still requires evaluation after extensive vehicle operation. Obviously, there is no short cut to evaluation of a new rear axle lubricant. Although laboratory bench tests and analytical chemistry are extremely helpful in screening and in maintaining quality control, they are of only minor value in judging a new material. Chrysler has verified this many times, with the result that our requirements include a group of axle tests. We do not believe that judgment of lubricant types can be made by individual bench-test machines such as the Almen or Timken nor by the amount of any specific element present.

The emphasis placed on the frictional properties of the lubricant is somewhat surprising. The effects of lubricant friction on the performance of limited slip differentials is, of course, well recognized; however, Mr. Gasvoda suggests that these properties may also influence drive line noises and perhaps period resonance with the axle gears. In 1957, Mr. J. E. Cardillo of Ford presented a discussion of rear axle noise to the American Society of Lubrication Engineers in a paper entitled "A Rear Axle Problem—Initial Axle Noise." Mr. Cardillo described these problems as essentially unrelated to lubricants, presenting what was, and is believed to still be, the consensus of the industry opinion. Our investigations over several years have repeatedly supported Mr. Cardillo's conclusion. If this is no longer the case, it should have a great influence on the development of future lubricants for axle gears. Perhaps Mr. Gasvoda can elaborate on this requirement, describing the relationship of frictional properties of the lubricant to quiet axles.

Chrysler's attitude closely parallels those indicated by both General Motors and Ford regarding concern for the

proper lubricant, and our policy on field lubricants is virtually identical to that described in the General Motors paper by Mr. Hunstad. We can also agree with Mr. Grance of Gulf in the desirability of having high-performance lubricants available in service stations.

Chrysler has used materials of the type described in specification MIL-L-2105B in the production of passenger cars since 1959 without difficulty. Our experience with the high-performance MIL-L-2105B lubricants has been entirely satisfactory since their introduction to the service market several years ago. This is now the factory lubricant for all of our standard production passenger car axles. Chrysler intends to continue to recommend only this type of gear oil for service use.

Our test experience shows the desirability of using lubricants at the 10-90 level on the CRC rating scale in service after break-in. It is recognized, of course, that not every car will require this margin of safety because of the particular driving conditions. We have found, however, that some problems may occur even at high mileage if the lubricant performance is significantly below 10. One of the most dramatic difficulties occurs when the differential cross shaft seizes on account of inadequate lubricant protection. For the past several months our gear development laboratories have been running a series of dynamometer and vehicle tests using commercial lubricants. One particular test emphasizing cross shaft problems involves a series of accelerations with one axle locked to provide complete differentialing. These tests correlate well with actual service experience related to sudden application of load during relative motion in the differential. Lubricants qualified as MIL-L-2105B show a degree of protection as high as 10:1 over many

well-known commercial oils of different types.

With respect to identification of service lubricants, we most heartily agree with Mr. Hunstad. We have attempted to support the use of API service designation GL-4 in our recommendations since 1960. To make this understandable, however, it has been necessary to include the words "as defined by MIL-L-2105B." The term GL-4 has often been misused and has resulted in extensive confusion and frequent misapplication. Axle and transmission tests have frequently been found to be useless because test personnel not acquainted with market practices and product identification selected incorrect lubricants. This is not a significant problem to anyone except the testing agency, but is indicative of the problems which can occur in the field. It would be difficult to establish how many times fleet operators have made similar errors. Our intention is to drop the expression GL-4 from our service publications, unless a realistic and understandable definition can be developed in the near future.

Significant advances have been made in the past several years in the development of new additives for gear oils. In many cases, the quality of base oils used has also been improved. New gear oil additives are being tested which show promise of further protection, greater reliability, and longer life. The contribution of individual companies have, therefore, been appreciable. But the problems of identification and, in some cases, availability of the desired materials remain essentially unchanged. The needs for cooperative activity are still great, and will probably remain so, despite the elimination of rear axle drain plugs and of the recommendations for periodic drains.

MR. J. F. COOK² (*presented in written*

² Research Department, Union Oil Co. of California, Brea, Calif.

form).—Mr. Grance is to be complimented for presenting an excellent case for Gulf's position in introducing the high-performance level gear lubricants in their retail outlets.

Union Oil Co. is in a somewhat different position in many respects. We operate in a considerably different geographical area. We also differ in being one of the few major oil companies that has not accepted these new oils into our product line.

For approximately 15 yr we have offered a MIL-L-2105 gear lubricant in our service stations. This lubricant has had an excellent service history in a wide variety of trucks and tractors, and for mill, farm, and other types of service. Like most MIL-L-2105 lubricants, it is not completely satisfactory in severe worm gear service. Since the requirements for a worm gear lubricant are quite severe in our area, we distribute a special product for this use. Generally, we do not market it through service stations; it is, however, available commercially and through a few truck stations.

When the more active MIL-L-002105B or GL-4 type oils were first being developed, their possibilities were of interest. We, along with others, witnessed the Yuma test inspections. In light of our past experience in our marketing area, we did not like the results. Although tooth surfaces were satisfactory, which pleased many observers, we judged the effects of sludge to be unacceptable with regard to performance that might result in commercial service on the Pacific Coast. In our commercial service, drain periods are much longer (40,000 to 60,000 miles), and the steep grades of the mountainous terrain often lead to higher temperatures than in the Yuma tests. We were afraid that the combination of a longer service time and a higher temperature would produce sufficient varnish, sludge, or decomposi-

tion products to interfere with proper lubrication.

To study this possibility, some field tests were run and these confirmed our opinions. Although corrosion was noted in the Yuma tests, in our tests it was obscured by lacquer and sludge, and we did not observe significant corrosion. In other tests, GL-4 products decomposed and oxidized so badly in severe tractor service that it was necessary to sand-blast the gear cases. In addition to our tests, which indicated that these oils would be unacceptable to our customers, several equipment manufacturers tested these high-activity oils and decided strongly against them.

We have had no measurable demand for the new type of product from our service-station customers. In fact, our latest information is that less than 3 per cent of the passenger cars in our marketing area are potential customers for the MIL-L-2105B lubricants, since the existing lubricants are performing satisfactorily. Our sales trends are in line with industry; and service complaints in either passenger cars or heavy-duty equipment are negligible. The sum of all these factors has indicated that the distribution of these high-activity lubricants as a very limited replacement for only a portion of the market already being satisfied by our existing product is an unjustifiable complication and of no benefit to our customers.

A minimum number of products is desirable for our customers and ourselves from the logistic and economic standpoint. Many problems arise from misapplication. I think we could all agree that it would be Shangri-La if equipment manufacturers and others could decide on one or two acceptable types of gear lubricants and could specify the requirements in realistic terms. Above all, any such definition must take into account typical service conditions and the customer's operating habits.

I do not say we shall not, at some future date, distribute a MIL-L-2105B product in our service stations, particularly if serviceable products can be developed. We have, in fact, recently changed to a new type gear lubricant which we believe will provide improved service for a wider range of applications than did our older product, but it is not a MIL-L-2105B product.

In the intervening years since the new high-activity lubricants were first introduced, we believe that our not supplying them has saved expense for our customers and ourselves. This has been done with no loss of performance to our customers or loss of sales to us.

It has been rumored that some of our western competitors who initially adopted the same products have been gradually deserting these oils in certain areas. It would be interesting if some of these people could say why they have reversed themselves.

MR. W. F. FORD³ (*presented in written form*).—Some of the papers in this symposium have referred to the ASTM assignment of defining by performance tests the API service GL-4 designation for multipurpose gear lubricants. During the past few years there have been many expressions of need for such performance definition.

To satisfy any doubts, Section III on Gear Lubricants of Technical Committee B of ASTM Committee D-2 on Petroleum Products and Lubricants has been charged with developing "a technical language for GL-4 lubricants." This symposium seemed an appropriate place for a brief status review, and to indicate some of the possibilities of performance tests for evaluating multipurpose gear lubricants intended for GL-4 service.

³ Chairman, Section III of Technical Committee B, Continental Oil Co., Ponca City, Okla.

This "technical language" task for GL-4 was originally assigned to the former Section G-IV of Technical Committee B. Section G-IV produced the Engine Test Sequences for Evaluating Oils for API Service MS.⁴ It was expected that the nature of the GL-4 tests would be similar to that of the MS tests—to determine suitability of the gear lubricant for its intended service by subjecting it to appropriate performance tests.

A special committee in Section G-IV was formed to develop a proposal of the tests which would express the GL-4 technical language. This special committee was composed of automotive manufacturer representatives who knew the test procedures employed by their companies in assessing gear lubricant performance in vehicles of their manufacture. Despite the absence of released information, this special committee made some progress. In fact, nearly all of the information to be reported was developed by the special committee before its activities were suspended by the 1961 reorganization of Technical Committee B.

Scope of Initial GL-4 Tests:

The API Service GL-4 designation for a multipurpose gear lubricant includes both passenger car and truck service at high speed and low torque, at low speed and high torque, using hypoid, spiral-bevel, and some worm gears, as well as some manual transmissions. This service range is too wide to cover at one time. The G-IV special committee wisely decided to confine its first efforts to one part of the range of GL-4 service—in passenger car and light truck hypoid rear axles. Such limitation is not intended to restrict in any way the carefully and explicitly worded API designa-

tion for "Multipurpose Type Gear Lubricant (API Service GL-4)." Neither is the limitation intended to preclude subsequent possibilities of one series of tests to cover the entire service range encompassed by GL-4. The initial limit merely served as a starting place for completing a complex assignment.

Probable Nature of Tests for Rear Axle Service:

The special committee of G-IV did receive the passenger car rear axle test procedures from the manufacturers of a large portion of the automobile production. As might be expected, there were similarities among some of the several tests submitted by each company. The committee felt that, with reasonable compromises, various procedures intended for one or very similar performance aspects might be combined into one procedure acceptable to all. To date, nothing has been done subsequent to receipt of the tests used by some manufacturers.

Unlike the MS test sequences which are conducted more or less as final performance tests mainly in production engines, the submitted gear lubricant tests include both laboratory and equipment performance tests. This probably is not surprising to those who are familiar with formulation, evaluation, and application of gear lubricants.

Liberty has been taken in broadly categorizing the automotive manufacturers' tests submitted in order that possibilities may be discussed in this symposium. The probable general nature of GL-4 tests is: in the laboratory—inspection and bench; and with equipment—rear axle on test stand and vehicle on the road tests.

Possible Laboratory Tests:

The kinds of laboratory inspection and bench tests that may become part

⁴ 1962 Engine test Sequences for Evaluating Automotive Lubricants for API Service MS, *ASTM STP No. 315*.

of the GL-4 technical language for passenger car rear axles are:

Inspection Tests:

- Viscosities at 0 and 210 F
- Pour point or channel, or both
- Flash and fire
- Water and sediment
- Precipitation number
- Saponification number
- Foam

Bench Tests:

- Oxidation:
 - Per cent evaporated
 - Viscosity increase
- Moisture corrosion:
 - Falex pin
- Load and friction:
 - Timken
 - Falex
 - Four-ball

Most of the inspection tests are ASTM standards. The low-temperature viscosity test may require the Brookfield viscometer. In the bench test category, the oxidation test probably will consist of long-time heating of the test oil in a beaker and then determining the amount of oil evaporated and the increase of viscosity during the heating period. The moisture corrosion test involves short-time operation of the Falex machine at moderate load and moderately high temperature to promote activity of the additives in the test oil. After the machine operation, the test pin is drained of excess oil and placed in high-humidity storage for 24 hr. There may be some surprise about possible inclusion of load and friction machine tests in a series mainly intended to determine performance in service equipment. Such kinds of tests may only serve as control tests.

Possible Equipment Tests:

GL-4 lubricant service in passenger car rear axles may be determined by the following kinds of equipment tests:

Test Stand:

- Two-differential wear
- Motored differential stability

Road Tests:

- Scoring:
 - Continuous high speed
 - Bump or shock
- Chatter:
 - Slow braked turns, forward and reverse
- Reverse noise:
 - Slow reverse upgrade and coast forward in gear
- Durability:
 - Several hundred miles of proving ground or service.

The names given to the above kinds of equipment tests and performance features to be determined are not official. They are used here only to indicate the probable kinds of gear lubricant tests to be conducted in production equipment.

Each of these equipment tests is conducted to determine the adequacy of one gear lubricant performance item. In addition, however, other performance aspects are observed, mainly as conditions of the gear and bearing surfaces, deterioration of seals, and extent of deposits. Only the general natures of kinds of possible gear lubricant tests in passenger car equipment are shown. Nothing has been done yet in agreeing on either the kinds of tests that are considered necessary or the details of each one.

Completion of GL-4 Technical Language:

Since the 1961 reorganization of Technical Committee B, the work of the G-IV special committee has been held in abeyance. The planning of this Symposium on Lubricants for Automotive Equipment started with Technical Committee B's reorganization. It was decided that the individual automobile companies should be given the opportunity to present their ideas about gear lubricant requirements at this symposium before reactivating the GL-4 technical language project. Work toward completion of the technical language for GL-4 lubricant for passenger car and light truck hypoid rear axles will be re-

sumed immediately. In addition, the collection of gear lubricant tests for truck and other heavy-duty equipment service is being organized. These tests will include gear types other than hypoid and manual transmissions. The emergence from them of the remaining tests to complete the GL-4 technical language is expected.

MR. A. TOWLE (*author's closure by letter*).—Germany excepted, European manufacturers who utilize hypoid axles invariably recommend, as a service-fill lubricant, one or more of the major oil companies' branded products suitable for

rear axles, all of which are of MIL-L-2105B or MIL-L-2105 type. Owners invariably follow these recommendations and either name the brand themselves or leave this to the discretion of their service station.

Our test experience has shown that two additives which are used with the same type base oil, at the same treatment level, to produce oils of CRC 10-90 level may give widely differing performances at identical but lower treatment levels, when tested under such other conditions as the Institute of Petroleum high-speed shock test procedure.