When bearings fail...

The need for improved, early-warning, hot-bearing detectors is clear. Acoustic detectors represent one approach. The use of onboard detection systems is another.

By GUS WELTY,
Senior Editor

You could make a case for the journal roller bearing as the most important component on a railcar—a device that costs not much more than $200 but one that can cost millions of dollars in damages if it fails.

Bearings produced by a dozen or so manufacturers may be out there on railcars today, but there are only two manufacturers in the market today, Brenco and Timken. Each goes to extreme lengths to ensure the quality of the product that goes out the door.

But bearings will fail. That's inevitable. And so, just as important as the research-and-development and quality-improvement efforts by the bearing manufacturers is the R&D that is under way to design ever-more-efficient systems to detect potential bearing failure well before an actual failure and burnoff takes place.

Infrared hot-bearing detectors have made a significant contribution to the safety of operations. But detectors are normally located 20 to 30 miles apart. And as more has become known about the nature and behavior of bearings—especially the phenomenon know as thermal runaway, in which a bearing can go from OK to burnoff in 60 seconds—it has become clear that improved, early-warning detection systems are needed. Use of acoustic detectors is one approach, being advanced mainly by Servo. Use of onboard systems is another, in development by General Railway Signal and Rastech.

What do bearing-related failures cost? Meaningful numbers are hard to come by. Figures used by the Association of American Railroads' Research and Test Department in its 1992 budget plan peg the costs of bearing-related derailments at something approaching $30 million per year, plus about $100,000 in costs associated with false alarms from detectors.

But reportable costs, under Federal Railroad Administration standards, do not include the costs of wreck-clearing, operations delays, detouring or re-routing. Lading-damage costs are not figured in, nor are costs associated with casualties. And of course there is no handle on what might be the most important cost in the long run, loss of a contract or loss of a customer.

When the roller-bearing truck was introduced, many years ago, the promise—or the hope—was that the hotbox would be a thing of the past. But things haven't worked out that way.

And in recent years, the potential for problems has been increased, as railroads go to higher speeds and heavier loads per car, and as cars—especially those in intermodal and unit-train service—rack up the high mileage that goes with efficient utilization.

The 263-pound maximum weight on rail has been exceeded in the past, with some experiences that worked out and some that were not so good. Now, increasing numbers of cars with a 286,000-pound rating are showing up. And at the Transportation Test Center at Pueblo, Colo., the Heavy Axle Load test consist continues to pile up the miles, and the millions of gross tons, testing 125-ton cars.

Ironically, almost all of the research and test work being done at Pueblo concerns the impact and the effects of heavier axle loads on the track structure. Impact and effects on freight cars and their key components—such as bearings—have not received much attention, except from equipment and components suppliers.

AAR R&T does have bearing-related projects on its schedule, looking at bearing-reconditioning standards in 1993 and a performance specification for new bearings in '94. But for now, it's up to the manufacturers to assess what it is that heavier loading will mean—and to determine how best to handle the inevitable problems.

• Acoustic and on board detection. Meanwhile, research and testing of improved detection systems continues, with Burlington Northern taking a leading role in both acoustic and onboard problem detection.

Tests of acoustic detectors have been under way for about four years, initially involving Servo and Harmon and BN at the TTC but Harmon later decided to redirect its R&D priorities.

The infrared detector—BN has them at 297 locations—is a device which "performs a last-ditch effort to recognize and call attention to a suspect roller bearing," in the view of Robert C. Leedham, manager-mechanical and electronics R&D at BN, but "an earlier means of detecting a defective bearing is needed, giving enough advance warning that a car need not be taken out of service immediately."

Currently, BN has the Servo acoustic system installed at six locations. The first system and the one that has been most monitored is near Alliance, Neb., on BN's central coal route. Its northern and southern coal corridors are covered by installations at Mandan, N.D., and Guernsey, Wyo. Two systems are working in the Minneapolis area, and the sixth is near Kansas City at a convenient "showcase" site where BN has also installed a dragging-equipment detector, a hotbox detector, a VideoMasters monitoring system and an Automatic Equipment Identification system.

BN has found that the acoustic detection system near Alliance "is functioning to remove defect bearings as originally envisioned with 85%-plus accuracy. Additional data monitoring and defective-bearing teardown inspections will be performed as the equipment is fine-tuned for the Alliance site-specific requirements. Hot journal setouts and burnoffs should decrease as defective bearings are removed from BN's fleet, utility cars and interchange cars."

But, Bob Leedham is quick to add, a lot of developmental work remains to be done in the area of system-enhancement. He sees the existing systems as a good learning tool, one that will get better as manufacturer and user get smarter about what it is they're detecting.

Will acoustic-detection systems become a major market? Probably not. Logically, these systems should be installed at points near where bearing work can be performed. At this point, Leedham sees BN as installing a maximum of 12 to 15 such systems, including the six already in place—and BN is the nation's biggest railroad in terms of mileage. The relatively small size of the market and the importance of the tool are two reasons why BN has been financially supportive of development and test work.

Then, there are onboard detection systems, in which a detection-device bolt replaces one of the conventional roller-bearing end-cap bolts.

Minneapolis-based Rastech has had sev-

BN/Servo acoustic hot-bearing-detection systems are now installed at six locations. Fine-tuning continues.

eral thousand bolts out for test, including tests on BN, Santa Fe and Illinois Central. This is a heat-sensitive bolt that fires out a visual indicator when the bearing exceeds a pre-determined temperature. Thus, it depends upon wayside observation in order to get a potential problem handled.

There have been problems. The company had about 2,000 bolts installed on BN cars, but as wheelsets came into shops for other-than-bearing-related problems, the Rastech bolts were tossed aside since BN wasn't re-using end-cap bolts. And, the company says, restructuring and personnel changes at Santa Fe have resulted in a test program there being put on "hold."

In the meantime, Rastech says it's in the early stages of developing a bolt that will fire and at the same time alert the locomotive engineer that his train may have a problem. (That particular development is one that hadn't been passed along to the leading railroad in detection R&D and test until *Railway Age* mentioned it.)

● **The Smart-Bolt.** At this point, however, the clear leader in developing an onboard system with the capability to warn the train crew is GRS, with the SMART-BOLT system that BN expects to begin testing in road service early next year.

Based on a patented device developed at Carnegie Mellon Research Institute, the GRS system uses a spread-spectrum radio-frequency transmitter and receiver, with the transmitter housed in a bearing end-cap bolt and the receiver/locator bracket-mounted in the locomotive cab. When a bearing hits alarm temperature, the thermal sensor in the bolt—a wax motor, similar to those used as thermostats in the auto industry for more than 20 years—uses expanding wax to force a piston to extend the head of the bolt to deploy an antenna and activate the transmitter.

The receiver/locator in the cab alternately scans each side of a train to detect a failed-bearing-alert signal.

Once the train is stopped, a crew member can then walk the proper side of the train, using the receiver/locator which then functions as a signal-strength indicator to help in locating the failed bearing. In addition, the head of the bolt is locked in an extended position, as an additional aid in finding the problem-bearing.

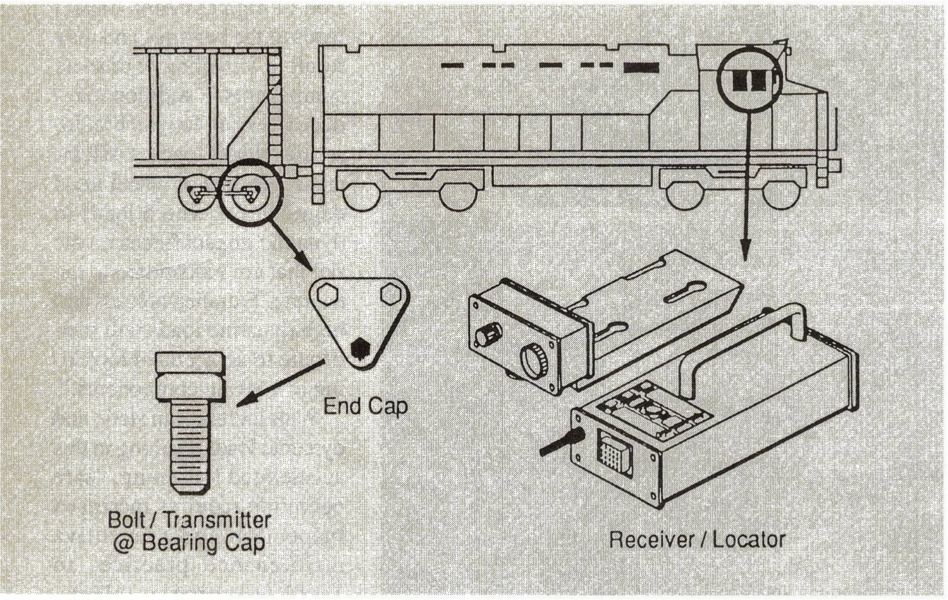
GRS is inviting railroads and/or others to participate in real-world service testing.

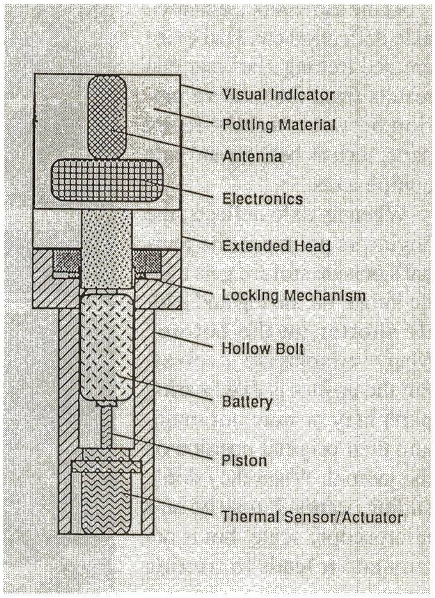
But in the meantime, BN is planning to test what Bob Leedham calls "a significant sampling of Phase I production model SMART-BOLTs, probably 10 car-sets in unit-coal-train service, to obtain extended environmental data, that is, wheel impact loadings, vibrations and adverse weather conditions.

These BN trains get greater than 100,000 miles per year in dedicated service. Says Leedham: "Not only will the thermal bolts be exposed to typical freight-car-truck accelerations and train slack action, but also to the environment at loading sites and at unloading rotary dumpers. The extended service evaluation will continue for approximately 200,000 miles, or a two-year period. BN and GRS will inspect the thermal bolts at approximately 50,000-mile intervals for component integrity, power source strength and alarm activation."

BN's people figure that initial applications will be on dedicated corridor unit trains, "with the eventual widespread use in rail and transit applications worldwide."

Averting derailments, Leedham says, "will save the railroads millions of dollars not only in lost capital equipment costs but also in claims and future business. Additional savings can be realized with a reduction in the number of false stops due to the accuracy of the system, and a reduction in stop duration due to the system's ability to identify





BN expects to begin testing General Railway Signal's onboard SMART-BOLT system in road service early in 1992.

the offending bearing. These reductions will result in less fuel waste, fewer maintainer calls, improved schedule adherence and greater customer satisfaction."

Those are the potential savings. But what about the costs to get the savings?

Leedham believes that installation costs "will be low compared to wayside hot-bearing detectors, as they can be installed in conjunction with regular scheduled bearing maintenance. Maintenance costs for the bolts are expected to be virtually non-existent. And, with onboard monitoring, it is anticipated that there will no longer be a need for wayside hot-bearing detectors and their high maintenance costs."

Leedham concedes, though, that the economics will get a hard look: "The work done to date has led to a prototype system whose effectiveness has been proven. The remaining challenge will be to utilize the knowledge acquired, to produce a commercially-viable product at a reasonable cost. To accomplish this will require the efforts of a broadly diverse team of experts in many fields of technology. Although there are still several potential technical limitations in the commercialization process, we're confident that the remaining technical issues can be resolved."

GRS is not talking about costs per bolt or per car-set at this point, for the excellent reason that a price can't yet be determined. Nor can a precise market be determined, and the size of the market will go a ways toward determining pricing.

There is always speculation, and some of the numbers talked about as speculation seem high, especially as compared to the cost of a standard end-cap bolt, which is how the device may be regarded by the uninitiated so long as it's called a bolt, even a smart one. But, even considering some of the high numbers rumored, the cost doesn't seem high if it could save a $50,000-and-up freight car from a derailment.

The idea has been, in conventional wisdom, that application would be in train-sets, unit trains in dedicated corridor service. Cars carrying hazardous materials would also seem to be excellent prospects, although equipped hazmat cars could fall victim to derailments caused by unequipped cars in mixed-freight service.

• Site-specific, equipment-specific. Could it be that someday the use of an onboard bearing-future-detection system would be made mandatory. It's unlikely.

The fact is that burnoff is by no means an everyday occurrence, disastrous though its results may be. BN, for example, had 19 burnoffs in 1988 and that's regarded as a typical year since the number of incidents seems to be staying at around that level. And the economics of equipping the entire fleet would be staggering, with close to 1.2 million freight cars now in service.

So, the strong likelihood is that application will be made in equipment-sets, for equipment getting heavy tonnage, high mileage, or both.

And installations of any new kinds of detectors may have to be both site-specific and equipment-specific. For instance, smaller-diameter wheels in use on some types of intermodal equipment tend to run hotter, and this can lead to the triggering of a detector even though the bearing is not distressed. Too, the depressed-well design of double-stack cars, combined with what amounts to side-skirting on some units, tends to limit the flow of air around the trucks and this can contribute to heat buildup.

As for state-of-the-art in bearing technology, both manufacturers can point with more than a little pride to advances that have been made, over the years, in a number of key areas. Seal technology is one, with Brenco calling attention to lower total operating costs provided by its SealTech hydrodynamic low-torque seal design, and Timken referring to its HDL seal and sleeve as the most innovative change in design in years.

Research is also being conducted in the area of developing improved lubricants and, importantly, in the area of bearing retention.

Studies have indicated that as much as 50% of all rail-service bearing failures are related to loose components. Brenco notes that it researched the problem and that major AAR rules changes were then made several years ago. This, the company's engineers believe, has done more to improve bearing performance than any other development over the past 10 years.

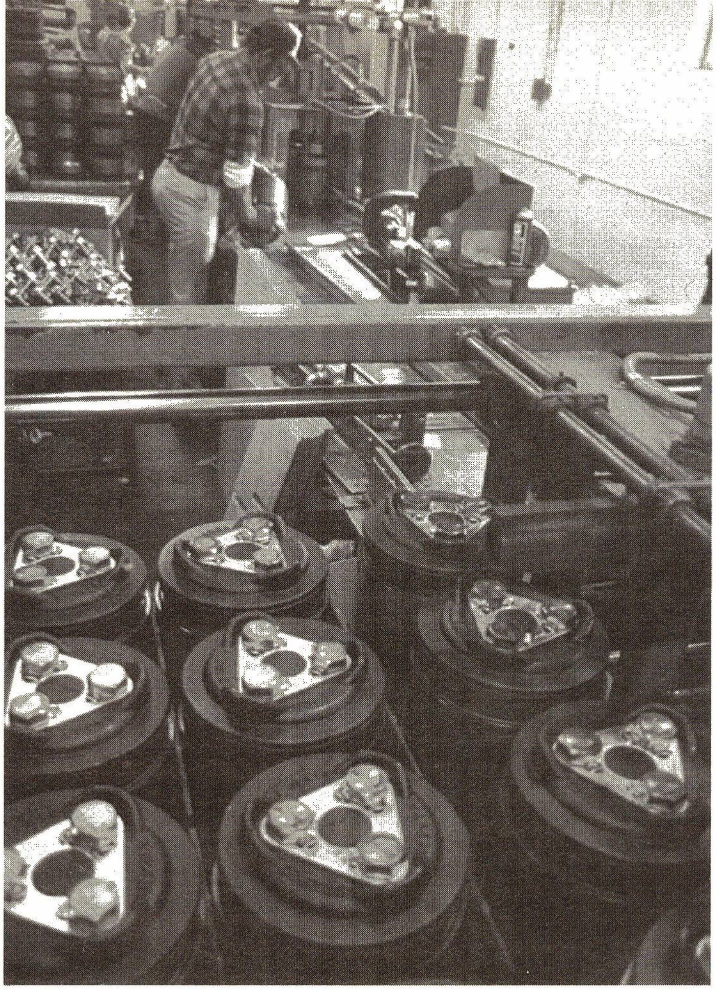
The changes, involving elimination of cap-screw seal rings, a requirement for lubrication of cap-screws and an increase in cone bore, had a double benefit. They reduced the incidence of loose-bearing-related overheating, and they reduced fretting wear.

But there are concerns now that increases in axle loads will work against the gains that have been made. Increased axle deflection involved with heavier loading may well require application of a more effective clamp load to keep the bearing stack stabilized, although the additional clamp that may be needed has not yet been quantified.

At the same time, increased axle deflection can lead to increased fretting, the wear that results from the relative motion between tightly-fitted parts, such as bearing and axle components.

When an axle deflects, the engineers point out, the journal's outside surface gets a little longer on the top and a little shorter on the bottom. Many variables are involved, but the upshot is that bearing parts may or may not maintain their original position on the journal. When they don't, sliding occurs. It may be on a microscopic scale, but it occurs and it leads to fretting wear.

Resulting face-wear means that the width of the components is reduced, and this means that there's a reduction in the overall length of the stack of bearing components. By this process, the engineers say, "fretting can eventually lead to a total loss of bearing clamp, with the potential for rapid bearing failure with possibly catastrophic consequences."



After quality **checks** at every step during the manufacturing process, bearings are moved through final assembly line at Brenco's Petersburg, Va. facility.

Brenco Product Engineering personnel are using finite element analysis modeling to try to determine the exact relationships between bearing clamp, axle load and fretting—and results thus far confirm an increase in axle deflection and axle stress with an 8.7% increase in load, which is what's involved in going from 263,000 pounds to 286,000 pounds.

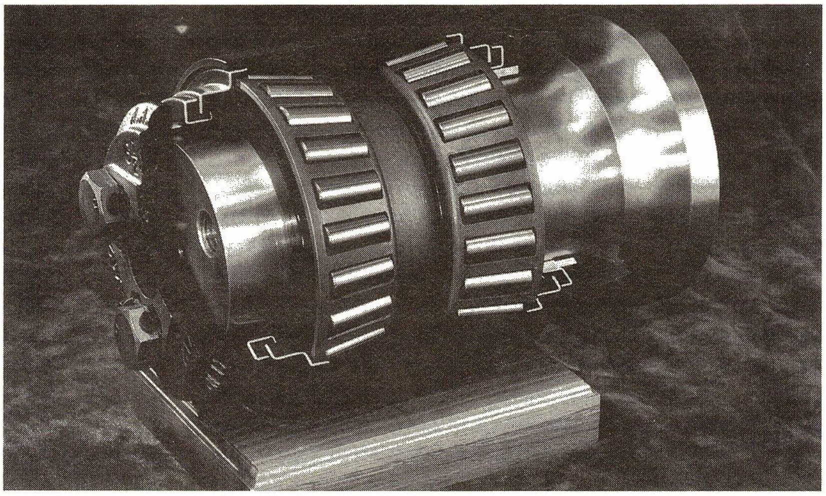
Timken's engineers also call attention to the fretting problem which, in actuality, "is unavoidable since the axle cannot be made perfectly rigid. Fretting wear over time leads to loosening of components and loss of cap-screw tension, which then can become an operating problem and therefore is a safety consideration."

But, the engineers note, other factors also influence bearing performance under heavier loads, factors involving other truck components which may be subjected to increased wear: "Wear to truck components will affect truck performance and result in extraneous loads to the bearing. Higher loads on existing trucks increases the possibility of springs going solid during loading operations or under dynamic conditions. Solid springs allow transmission of high dynamic impact loads to the bearings and may result in brinelling or cracked components in addition to reduced bearing fatigue life. Increased wheel loading will increase the rate of wheel tread degradation, which leads to dynamic impact forces on the rail that are transmitted to the bearing. Extraneous loads and high dynamic loads will contribute to accelerated loosening of bearing components."

With increases in static and dynamic loads resulting in this accelerated loosening, "safe operation requires increased inspection and preventive maintenance practices to avoid operating problems. With the proper inspection and preventive programs, the question of increased load again becomes an economic consideration for the cost of these programs."

Like responsible suppliers in all areas involved with heavier axle loads—equipment suppliers and track-component suppliers alike—the two bearing manufacturers believe the new challenges can be met, as past ones were met, if there's a clear understanding on the part of all concerned as to precisely what these challenges will be and how they out to be met.

Railroad maintenance officers know that increased loadings are here today and that the trend will grow, if the economic considerations related to marketing and the need to remain competitive dictate that they grow.



BN and Timken have said they consider Timken's Hydrodynamic Labyrinth Seal (HDL) the most significant development in bearing technology since Timken introduced the Ap bearing 37 years ago.

Maintenance officers are convinced that heavier loads can be operated safely, if all the implications for maintenance—especially preventive maintenance—are understood.

Research-and-development work under way with both the bearing manufacturers and the manufacturers of detection systems should go a considerable way toward bolstering the safety factor—for existing equipment and for any new equipment. ■