

Can acoustic detectors reduce bearing failures?

Devices that "listen" to passing trains to detect troubled bearings could be a DEW line of defense against failures. They would complement, not replace, infrared detectors.

The roller bearing as applied to the freight-car truck is a highly-efficient piece of technology that hardly ever fails. But when it does, that failure can be both sudden and catastrophic.

The infrared hotbox detector is also a highly-efficient piece of technology, capable of picking up heat signals and giving warning to a central location and/or to a train crew.

But today's detectors were originally set 25 to 30 miles apart, a range that would detect plain journal bearings that were about to give a problem. Roller-bearing failure, if it happens, can occur far more quickly.

That's why railroads, detector manufacturers and bearing suppliers are all looking at better ways to protect against and prevent bearing failure.

Two manufacturers and a number of railroads are deep into development and testing of acoustic detectors. At least one railroad is working with this technology while installing its own, which will provide for much closer spacing of detector units.

What this adds up to is that Servo has worked with Conrail and Union Pacific, has had a test unit in place since last spring in Georgia on Norfolk Southern, and is in the advanced development stage with its acoustic detector. Harmon, meanwhile, has been working with Burlington Northern and UP and will have a unit installed on BN for in-service testing in November. Both manufacturers have had detectors in test operation at the Transportation Test Center at Pueblo, even as TTC was running tests on conventional detectors to see if, among other things, they could adequately handle certain problems presented by use of single-axle trucks on some of Trailer Train's new intermodal cars.

And while all of this research-and-development-and-test work goes on, Norfolk Southern is confidently installing pyroelectric, rail-mounted detector systems of its own development at a cost that will allow it to space these units close together.

The roller bearing was introduced into freight-car journal use about 35 years ago.

Roller-bearing trucks, as opposed to plain-bearing trucks, reduced freight-train stops for setouts and they reduced the number of accidents due to overheated journals and axles.

But each advance can have a disadvantage. In the case of the roller bearing, it lies in the speed of failure if a failure is going to occur. The Track Train Dynamics program put it this way: "The immediate concern about the roller bearing is the final stage of failure, which is the seizure process. Roller bearings generate tremendous amounts of heat in a very short period of time during the final phase of bearing failure. This bearing disintegration phase is believed to be different for the roller bearing. . . . The final stage, ultimately leading to a journal burn-off, occurs in a relatively short distance, one to two miles."

As TTD put it, two research courses were begun, one to quantify the mechanisms of final bearing failure so as to aid in development of better wayside detection methods, and the second to rationalize reconditioning standards and improvements in wheel/bearing shop inspection techniques.

● **A distant early warning.** The first course was to focus on "improved wayside detector reliability and/or sensitivity and the development of non-heat-base detection systems."

That's a course that Harmon and Servo have followed with acoustic detection. In each case, the manufacturers do not suggest that acoustic detectors replace infrared detectors. Rather, they suggest that sound-detection systems should be used in a preventive mode, making it possible for a railroad to do preventive maintenance before a bearing gets to a critical stage.

In its plan for use of acoustic detection, for example, Harmon proposes that detectors be located near a service facility that can change-out a wheel set.

What acoustic detectors can do, it appears from tests thus far, is to provide a DEW line, a distant early warning system that will detect a potential problem before it becomes a real one.

Harmon sees benefits in four major areas

from use of an acoustic bearing analyzer system:

—To identify bearings before they can become critically hot.

—To reduce the potential for a catastrophic failure.

—At the same time, to reduce the number of unnecessary train stops made because of conventional detector readings: "Roller bearings have been known to exhibit increases in temperature periodically and then run at normal temperatures. These bearings may be identified before they exhibit characteristics that might result in train stops."

—To make possible the recovery of bearing parts before they become irreparably damaged.

● **What it is, how it works.** As outlined by Lawrence H. Luzynski, design manager-train inspection systems, at the 1988 meeting of the AAR C&S Division, trackside equipment consists of the acoustic sensor element, a pair of wheel transducers and an advance start mechanism, with a processor unit located in a trackside instrument house. Major functional parts of the system consist of an amplifier section for the acoustic sensors, a filter stage and a processor unit equipped with appropriate interface cards.

As a train passes the detector, Larry Luzynski explained, if a defect indicator is discovered in a first-pass analysis, the bearing is archived for post-train analysis. Post-train analysis—which, it's hoped, will take place in a matter of minutes—will examine archived axles "in greater detail for the specific defects. Those axles that are selected for inspection and/or service will be marked and the train record will detail the reason for the selection."

Harmon's research-and-development work came at the request of BN, that a study be made of the feasibility of electronically listening to passing trains in order to identify roller bearings with mechanical defects. Tests were run in cooperation with BN and UP, and at Pueblo. There, "known mechanical defects were introduced into the train consist. Acoustic sensors were installed

trackside to examine and record the signatures of the defective bearings," and as a result of all of this work Harmon developed the ABA, Acoustic Bearing Analyzer, system that will go into prototype testing on BN next month.

• **Servo's findings.** Servo, meanwhile, began engineering design of an advanced development system in the summer of 1986, choosing to add acoustical detector functions to those of the Servo System 9000 hotbox detector "to utilize advantageously

all of the extensive automatic features of that microprocessor-based system." Servo added and integrated two trackside acoustical sensors, an acoustical signal processor and a Datagraph Chart Recorder/Printer for acoustical data.

The first acoustical test was run on Conrail. Since then, tests have been conducted on Union Pacific, at the TTC in a BN-sponsored program, and on Norfolk Southern.

Among the conclusions reached, says

Joseph E. Bambara, vice president-corporate advanced development for Servo: "Deployment of these systems has demonstrated that defective bearings can be detected automatically by the noise they emit. Early acoustic detection by wayside systems facilitates cost-effective follow-up corrective action at yard locations. Integration of an acoustical detector with a hotbox detector provides a backup warning of imminent bearing failure. . . . When acoustical detection is correlated with hotbox detection, an acoustically-detected bearing defect with abnormal heat can indicate the bearing is near failure. An acoustically-detected defect with no abnormal heat can provide early detection where corrective action can be taken when economically convenient at a yard location."

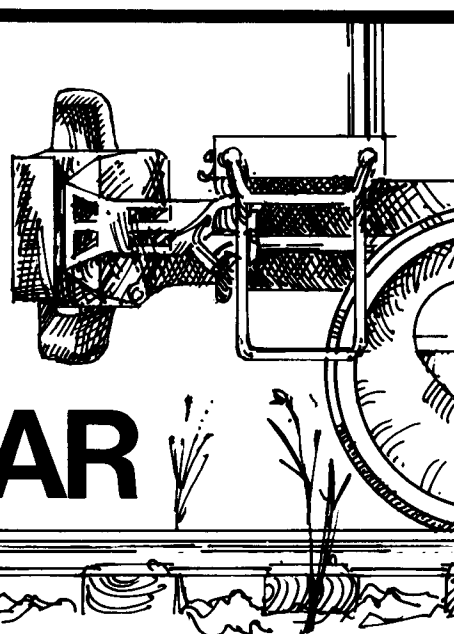
Bambara described the first advanced development system on UP, a system in operation to monitor unit coal trains, in a C&S Division presentation, and followed that with outlines of later system installations at TTC and NS, in presentations last month to the International Wheelset Congress and the Car Department Officers Association.

In the TTC/BN program, which ended in May, bearings with known defects were deployed in two test-train consists, with operation loaded and unloaded and a variety of speeds. Test sequences, Bambara noted, "provided an opportunity to gather acoustical signature and background noise data and an opportunity to check and adjust the realtime performance of our system, over a very broad range of variables. . . . We were able to identify many of the defects such as cup, cone and roller defects with reasonable consistency. Some others, such as loose backing ring and loose cone, were only identified occasionally." After updating, that test unit went back into service on BN at Alliance, Neb.

Servo's test on NS north of Atlanta has been working since last March, monitoring a mixture of traffic at speeds in the 40- to 50-mph range, with alarms reported by telephone dial-up to a printer and with a quick-response grease gun used to mark alarm-associated wheels (this method is to be used only until a television identification system is installed).

Operation of the guns has given problems, in two of three evaluation tests conducted thus far. But in the second test, for 13 defect alarms, 10 associated with properly-marked wheels were found to have defective bearings. And in the third test, alarms led to teardown of 19 bearings. One was a "nothing found," associated with a severe wheel squeal—and 18 were bad bearings.

(Continued on page 46)



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Acoustic detectors

(Continued from page 40)

In the three evaluation tests, in total, Bambara says, "We have eliminated 33 bad bearings by automatic acoustical alarms. Additionally, on teardown, we have found a relatively high incidence of about one in four bad mate bearings on the opposite axle end of an alarmed bearing. Seven such bad mate bearings have been removed. Thus, to date, at least 40 bad bearings with a variety of condemnable defects have been removed from service—bearings that otherwise would still be operating and awaiting an AAR 'Hand Test' associated with wheel maintenance, or awaiting a hot-bearing detection with associated train delays, or ultimately a burn-off."

Test data collected in just a couple of years indicate strongly that acoustic detection has a future. More data will be coming, from Servo's installations on UP, BN and NS and from more installations now planned, as well as from Harmon's test of the ABA prototype on BN.

But at this point, acoustic detectors, used in conjunction with infrared detectors, appear to have proven out—not just as a backup but, importantly, as devices that can in fact give much-needed early warning of impending bearing failure.

● **NS strategy.** The history of railcar roller-bearing failures shows that they are statistically insignificant. But they happen.

As Norfolk Southern saw the problem, it was one of preventing a burn-off which is so



Norfolk Southern has been testing rail-mounted pyro-electric scanners at 10-mile intervals.

costly that it can't be tolerated, without going to a solution which is so expensive that it can't be easily justified.

Norfolk Southern's Robert W. Ralph, manager-research and development-communications, put the NS approach succinctly at this year's AAR C&S Division meeting: "Norfolk Southern chose to change the equation."

NS decided that "if a more economical version of our existing and proven infrared heat-detection system could be developed, the equation could be radically altered, not only to provide better protection on existing lines but also to provide protection on lines or routes not currently protected."

NS set the goals: "The new system would have to be at least as good as our

current system with its 25- to 30-mile spacing and with full-time tape analysts. It would have to be more reliable in order to minimize or eliminate the need for additional personnel to maintain the increased number of detectors. It would have to be stand-alone, self-checking, self-analyzing and self-announcing with no human intervention. It would have to provide for defective journal protection with accommodations for auxiliary inputs for hot-wheel, clearance and dragging-equipment detectors."

Late in 1986, NS developed a rail-mounted pyro-electric scanner which provided an up-and-in-looking outboard bearing scan. It was coupled to an amplifier which was connected to a microprocessor for comparison of scan results with a set of criteria for stopping a train. The microprocessor was given the ability to "talk" and a transmitter. The result, said Ralph, "was an economical machine with the ability to scan trains, count axles, evaluate data and announce the scan results via radio."

The unit could be installed for less than \$10,000. By comparison, Norfolk Southern's Mark I detectors cost about \$80,000 per site, and commercially-available units, Ralph notes, run a lot more than that.

Last year, NS began testing 13 pyro-electric detectors spaced at 10-mile intervals on its Georgia Division, a line equipped with Mark I detectors which could serve as a reference for the test units. As tests continued, NS made improvements in several areas to improve accuracy and reliability. NS also installed test units in Kentucky and Illinois, to prove-out the units under adverse weather conditions.

Test results, Ralph said, "have been ideas tried and modified—some trains falsely stopped with no problems found, but several trains stopped and cars set out prior to their being detected by our conventional system. At least two of these would not have made it to the next conventional detector without burning off, thus confirming the validity of our closer-spacing concept."

Since it's rail-mounted as opposed to track-side mounted, the NS unit avoids scan problems that are created by tie deflection under traffic. The detector is designed and built for mechanical survivability and it is not bothered by false electrical signals caused by shock or vibration.

Through the rest of this year, Ralph says, NS plans to install 60 to 80 more pyro-electric detectors, and "we fully expect to eventually replace our existing Mark I hot-box detector systems with these new detectors spaced at closer intervals." ■

ADVERTISER'S INDEX

ABBA	24	Miner	28
Adams & Westlake	CG30	Morrison Knudsen	CG40, 32
Alcatel	CG13	NewMar	23
Association of American Railroads	9	Passenger Transportation Specialists	CG34
Beacon Gage	24	PBI	CG36
Bombardier	CG23-26	Penn Bus	CG19
Brenco	CG20-21	Pettibone	36
Burlington Northern	BC	Power Parts Sign	22
Danella Rental	CG38	Pullman Leasing	17
DMV	23	Rails	10
Dofasco	CG18	Railquip	15
Dowty RFL	CG35	Railway Education Bureau	CG37
Ebonex	CG32	Railway Tie Association	IFC-3
Farr	CG33	RAM Communications	CG19
GATX	CG37	Riedel Omni Products	CG2
General Farebox	CG9	SAB Nife	CG28-29
General Railway Signal	CG30, 32, 34	Santa Fe	12
Hasler	27	Sutrak	CG10
Herzog Contracting	CG39	Swing Lo	CG36
Hill International	CG17	TAD	11
Keystone	41	Tamper	30
Kidder Peabody	42	Thermon Manufacturing	10
Kim Hotstart	21	Thrall Car	37, 38
La Materiel de Voie	35	Timken	4
Loram	IBC	Trailer Train	CG35
LS Transit	CG22	UKM	CG27, CG38
Lubriquip	16	Union Tank Car	40
Microphor	CG31	Unit Rail Anchor	6
Midwest Steel	5	UTDC	CG6
		VEAM	CG31