Predicting the life of hydraulic hose

New monitor warns of impending hose failure.

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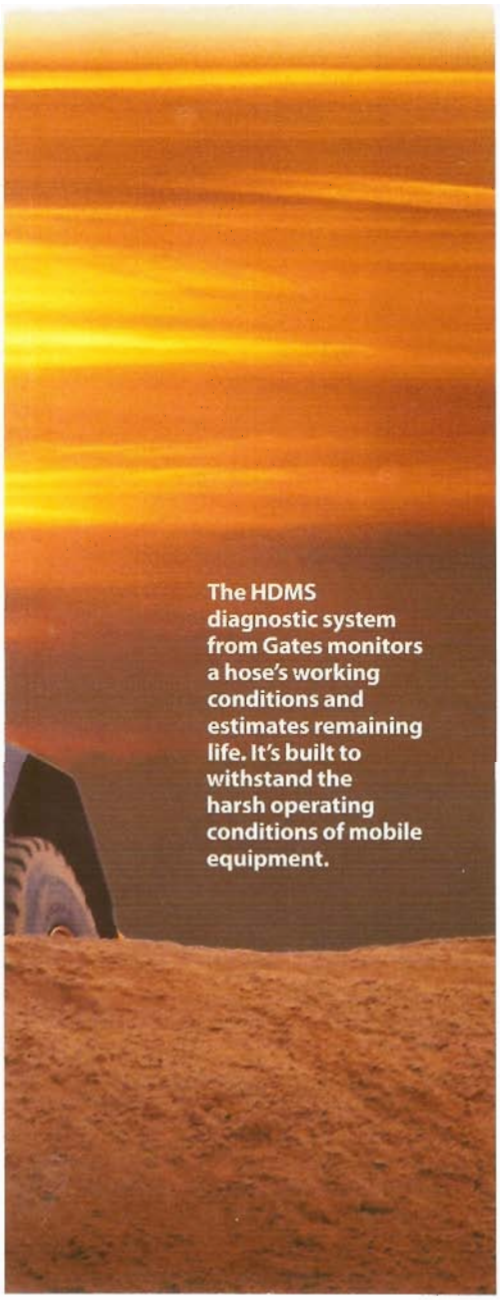
Key points:

- Unexpected hose failure can pose a safety hazard, cause expensive downtime, and require costly repairs and cleanup.
- HDMS monitors pressure and temperature in a hose and gauges its remaining life.

Resources:

Gates Corp., *www.gates.com*

Schrader Electronics, *www.schraderelectronics.com*



The HDMS diagnostic system from Gates monitors a hose's working conditions and estimates remaining life. It's built to withstand the harsh operating conditions of mobile equipment.

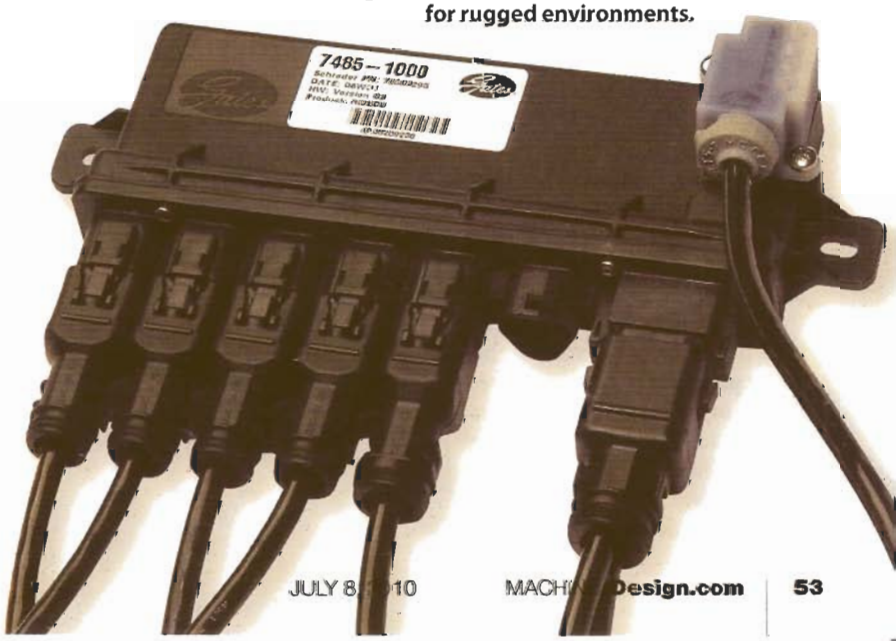
Downtime at mines and construction sites, on wind turbines and drilling rigs, and in steel mills and manufacturing plants have at least one thing in common: it can be expensive. It's especially problematic when hydraulic hose suddenly fails without warning. That poses a hazard to workers and surrounding machinery, not to mention the costs related to repair, cleanup, and lost production.

To improve uptime and productivity and lower operating costs, engineers at **Gates Corp.,** Denver, Colo., developed a system that warns of impending hose failure. Called the Hose Diagnostic & Monitoring System, or HDMS, it lets equipment operators avoid breakdowns and keep hydraulic systems up and running. By estimating how close a hose is to the end of its life and, when appropriate, issuing a warning, HDMS alerts maintenance technicians to proactively replace an assembly before it fails.

Previously, about the only way to gauge the health of a hose was by an imprecise visual check. "In essence, HDMS performs a daily inspection of the hose from the inside out and provides information that helps avoid catastrophic failures," says Joe Skovrinski, a condition-monitoring engineer with Gates.

"Building diagnostic capabilities into our hose and performing predictive maintenance helps customers better understand how equipment is actually being used and, thus, operate it more efficiently," he adds.

The ECU collects and stores data and performs life calculations. The cabling uses Deutsch connectors built for rugged environments.



HDMS is generally intended for high-value equipment, processes where unexpected downtime is costly, and where spills would pose a significant environmental risk. Examples range from hydraulic safety valves on oil rigs to ag equipment, where farmers may have only a narrow window to harvest crops before they rot. Failure of the hydraulic brakes in a wind turbine can let the blades spin out of control and possibly self-destruct. And in mines, not only is lost production costly, oil spills now demand cleanup and environmental remediation. "It's lost money that will never be recovered," says Skovrinski.

HDMS can also help make equipment safer, reduce warranty costs, and let OEMs build on existing diagnostics and predictive-maintenance programs.

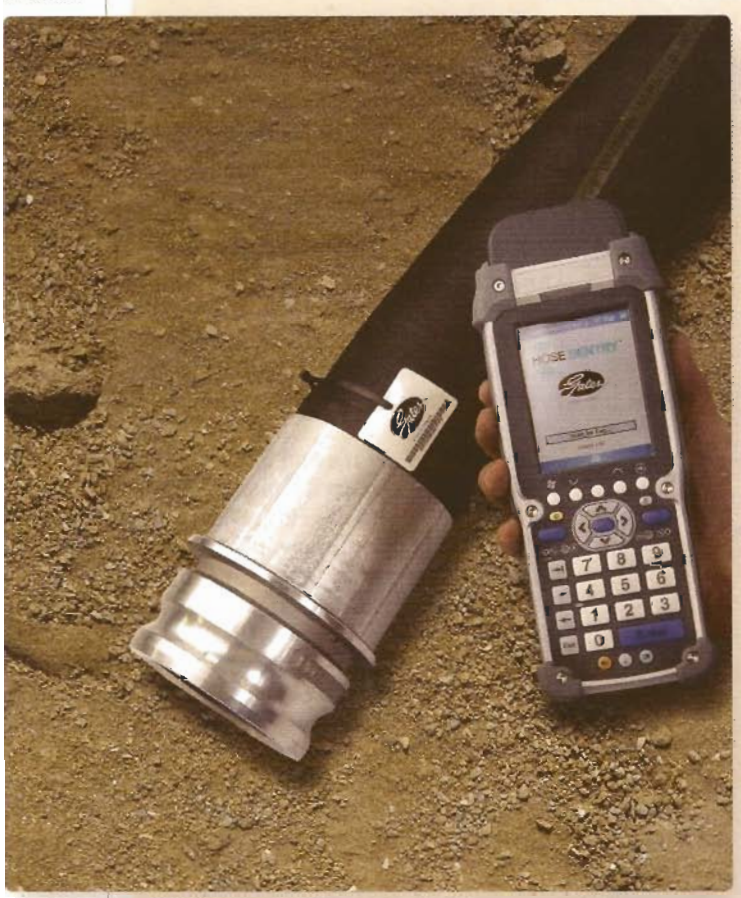
HDMS basics

HDMS consists of a network of sensors, controller (ECU), and software that monitors hydraulic-system operations and gauges its effect on the hose. Four hybrid pressure-temperature transducers in the hydraulic circuits send data to the ECU. Pressure range is 0 to 8,000 psig and temperature range is –40° to 250°F.

It's usually not the pressure per se but pulsations, the spike and release of pressure, that shorten hose life, explains Skovrinski. Gates defines a spike as a pressure surge of at least 133% of working pressure followed by a decrease of at least

RFID for field identification

Predicting impending hose failure is a critical advance in hydraulic technology, but it's not the whole story when it comes to proactive maintenance. Technicians also need to know details about the replacement hose — including type, size, length, and end fittings — to quickly repair and return equipment to service.



RFID tags speed and simplify hose-assembly identification. Technicians scan the tag using a PDA with an RFID reader, which then displays information such as the type of hose, end fittings, and length.

Identifying hose isn't always easy. On a dozer, for instance, the hose might endure years of dirt, abrasion, weathering, and abuse that obscure external markings. Or it might be painted or mounted in an inaccessible location inside the machine that makes the markings difficult to read.

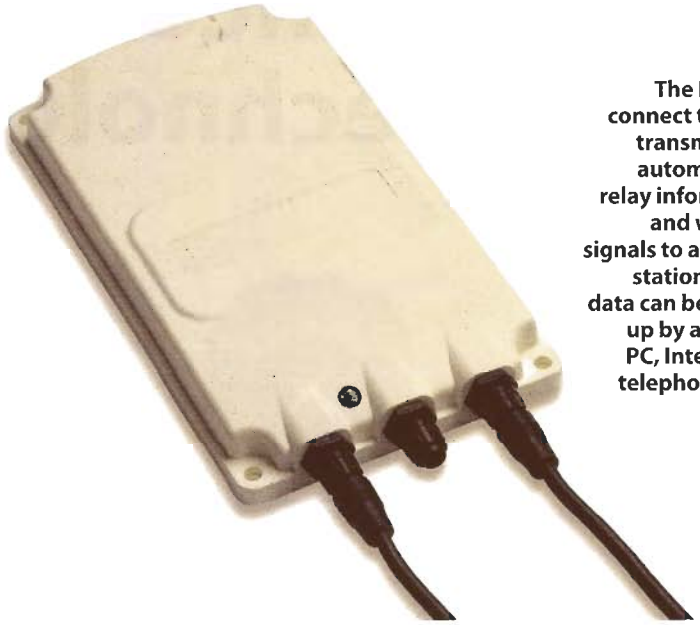
Gates now uses RFID (radio-frequency-identification) tags on hose assemblies to speed and simplify identification. This gives operators and maintenance personnel instant access to hose-assembly information, letting them quickly make a new assembly or order replacement parts.

The tag attaches to the hose and stores unique information about the assembly. Gates technicians or fleet managers maintain a database that stores the tag's identity and hose specs. Should an assembly require service, maintenance personnel scan the tag using a PDA with an RFID reader and call up information from the database. Operators can also update and add hose information via the handheld device. Data in the PDA and main database are synchronized at regular intervals.

According to Gates engineers, RFID offers advantages beyond speedy turnaround. A simple but comprehensive hose tracking and identification system lets hose suppliers monitor quality and inventory. And RFID provides information that ties hoses being built to how they're being used, potentially permitting more-informed hose selection that results in even less downtime.

50% from the peak value. Because rapid pressure fluctuations are common in hydraulic circuits, HDMS collects pressure data at a 50-Hz rate.

Temperature can also have a significant effect on hose life, says Skovrinski. Experience shows that temperatures within 20% of a hose's upper or lower limits amplify the negative effects of pressure spikes on hose compounds. The temperature transducers take readings once per second.



The ECU can connect to a GPS transmitter to automatically relay information and warning signals to a ground station, where data can be picked up by a remote PC, Internet, or telephone SMS.

Calculating life

Transducers transmit data via 4-to-20-mA signals to the ECU over wire lengths of up to 7 m. The ECU, developed by Gates and manufactured by sister company **Schrader Electronics,** Belfast, Northern Ireland, stores and crunches the data. The heart of its life-prediction software is an algorithm based on the SAE J1927 Standard. But years of test data and simulations have led Gates engineers to refine the calculations to better match actual results.

Here, in essence, is how it works. For hydraulic hose operating within spec, at moderate temperatures, and with no pressure spikes that exceed the 133% point, life will diminish at a linear rate over time from 100% to failure at 0%. The Gates algorithm takes into consideration the detrimental effects of pressure spikes and temperature extremes on this baseline, and predicts a decrease in estimated hose life based on the cumulative impact of these factors.

How well does it predict hose failure? It's accurate to within about ±10%, says Skovrinski. So by setting a limit, say at 20% of remaining estimated hose life available, HDMS will issue alerts as life approaches that 20% mark within ±10%. The OEM or user can specify at what point in the hose's remaining life the warning is issued. For instance, the limit could be more conservative when failures cannot be tolerated.

The HDMS works with most types of Gates hydraulic hose, despite differences in reinforcement, temperature rating, and operating pressure range. "That's significant because this algorithm works across our entire range. We're not limited to a specific type of hose," says Skovrinski.

It also warns of out-of-spec conditions, such as overpressures or excessive temperatures, as well as failure of sensors or the ECU. However, the device does not monitor for damage caused by abrasion, physical abuse, climate, or other external conditions.

The basic HDMS indicates fault conditions through an LED display. Technicians can also connect a laptop PC to the ECU to download more detailed data. In the most-sophisticated version, the ECU connects to a GPS or cellphone transmitter to automatically relay data and warning signals to a ground station, where data can be picked up by a remote PC, Internet, or telephone SMS. Updates are sent once every 24 hr via a cellular call or satellite link. Alarms, however, are sent every 5 min until acknowledged.

System setup

A menu-driven configuration program lets technicians specify parameters required by the cumulative-damage algorithm, such as the number and types of hoses, their locations, and at what point prior to failure to issue warnings.

Transducers are generally placed in the most heavily taxed circuits, such as lines subject to high-frequency cycling, shock and impact loads, and pressure extremes. Each transducer can monitor up to six different hoses in a single hydraulic circuit, provided all lines see similar pressure spikes and temperatures. The types and sizes of hose in the circuit are specified during setup, and the software applies appropriate damage algorithms to each.

The rugged design is built for mobile and stationary applications. Sensors are rated for ambient temperatures to 250°F and carry an IP67 rating (suitable for pressure wash downs). The ECU handles ambient temperature to 185°F and has an IP65 rating (spillage and dust/dirt protection). Cabling uses Deutsch connectors, designed for harsh environments where dust, dirt, moisture, salt spray, and vibration can contaminate or damage electrical connections and equipment. It runs on 8 to 30-Vdc power.

Currently, mobile-equipment manufacturers and dealers in the U.S. and Europe are evaluating HDMS for both new designs and as an aftermarket option. It's also being tested on stationary equipment. **MD**

Examples not shown to scale

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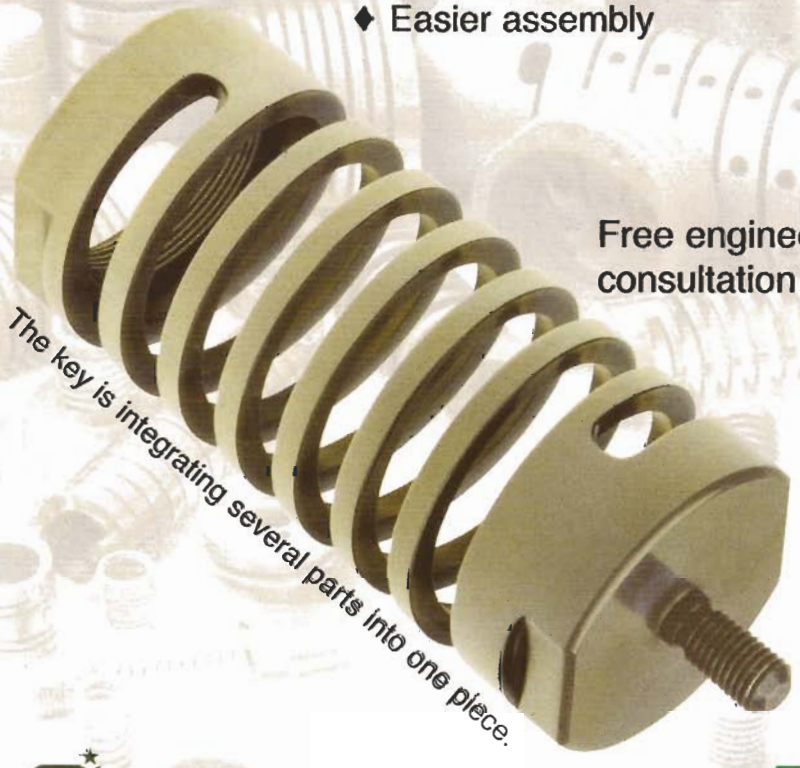

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