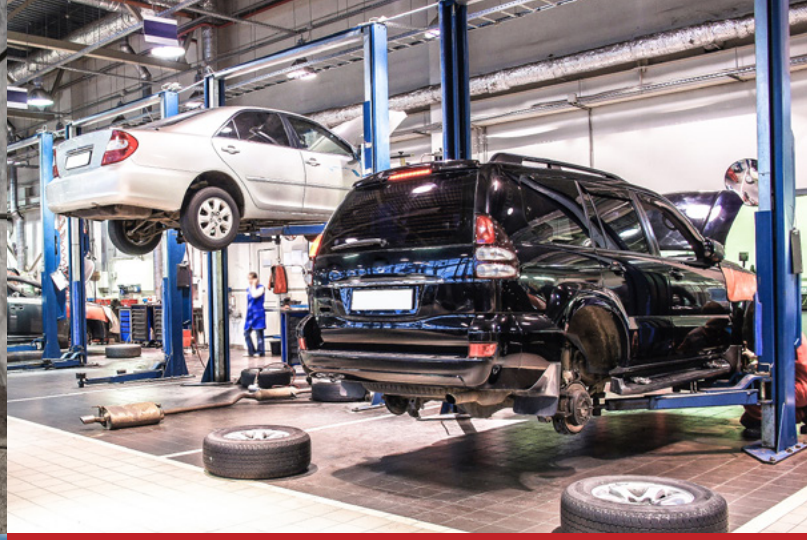


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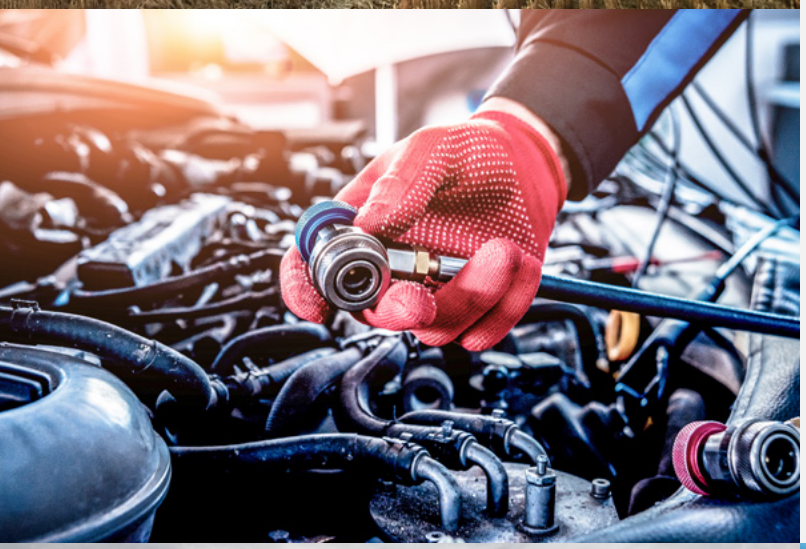
INNOVATION IN THE HYDRAULIC HOSE INDUSTRY

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We are living in an age of innovation for the hydraulic hose industry, and manufacturers continue to explore new technologies to accommodate increased market demands and the evolving needs of applications. Equipment in industries like construction and agriculture are demanding tougher industry standards for more-compact hydraulic systems with increased power and performance. Manufacturers of hydraulic hose and couplings are rising to the occasion by leveraging materials science to deliver innovative products led by advancements in composite rubber elastomer, manufacturing processes, and tools for hydraulic assembly applications. The results are time and resource savings while increasing performance and reducing downtime.





ENGINEERING STANDARDS INCORPORATE GLOBAL VIEWPOINT

Market requirements for hydraulics continue to evolve, driven by both higher performance requirements of innovative systems as well as the globalization of equipment platforms within industries like construction and agriculture.

Historically, hydraulic hose and coupling standards were regionally focused. For example, the Society of Automotive Engineers (SAE) maintained standards for North America, the German Institute for Standardization (DIN) for many parts of Europe, and Japanese Industrial Standards (JIS) for areas in Asia. Variations among regional standards for performance measures such as working pressure, burst pressure, hose dimensions, and temperature range not only created confusion for customers and OEMs—especially when designing a product for global use—but they also added complexity for hydraulic manufacturers tasked with developing multiple similar yet unique products.

Fortunately, standards organizations have aligned requirements and specifications in recent years such that a single hydraulic hose can now often meet multiple regional standards. Furthermore, the International Organization for Standardization (ISO) has issued hydraulic hose standards such as ISO 18752, which are truly globally applicable.



Consolidates inventory

Simplifies hose selection

Meets diversified applications

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SHIFT TO PERFORMANCE REQUIREMENTS SIMPLIFIES HOSE SELECTION

Traditional hydraulic hose standards defined by SAE, DIN, or JIS focused more on hose construction attributes (spiral or braid reinforcement, number of reinforcement layers, dimensions, etc.). The ISO 18752 standard shifted away from defining hydraulic hoses by construction to instead focus on hose performance. It specifies hoses by constant pressure ratings, operating temperatures, and number of impulse cycles for several varying levels of performance—from 200,000 up to a million impulse test cycles. This simplifies the hose selection process for design engineers and allows the hydraulic system to be optimized for duty cycles ranging from light to severe duty. By not defining standards by material or construction requirements, ISO 18752 also frees up hose manufacturers to innovate hydraulic solutions designed with new materials and processes that meet or exceed the defined performance levels.

At first glance, all hydraulic hoses may look similar, but today's hoses are highly engineered elastomer composites made to exact specifications. The main components of all hoses are a tube to carry the fluid, reinforcement for strength, and a cover to protect both **(figure 1).**

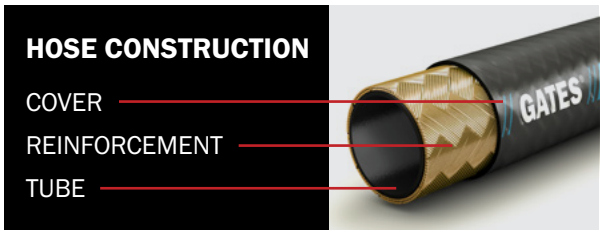


figure 1

Hose materials must be carefully selected and designed to work together to provide the optimal balance between working pressures and flexibility. Recent innovations in both materials science and process engineering have enabled hose designers to elevate hose performance and features to new heights.

Today, tube elastomers can handle chemical compatibility for a wider variety of petroleum-based and synthetic hydraulic fluids at higher temperatures—up to 300°F/150°C. The wire braid reinforcement combines new, high-strength steels with advanced braiding methods to produce a higher-density wire pack for greatly increased hydraulics system pressures in the same hose size as traditional hoses. Modern-hose cover materials leverage advanced compounding technologies and leading-edge materials science to enhance abrasion and temperature resistance without sacrificing ozone resistance, flexibility, or any other practical performance parameters.



Hydraulic hose couplings have also benefited from advanced metallurgical engineering and plating processes to increase corrosion resistance to over 10x the industry standard for salt spray tests using more environmentally friendly materials.

These innovations in materials science result in modern hydraulic hose assemblies that greatly outperform previous generations.

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TAKING A CLOSER LOOK AT HOSE DESIGN

OUTSIDE DIAMETER – CROSS-SECTIONAL SPACE

Since dash size (e.g., -16) refers to the inside diameter (I.D.) of a hydraulic hose, by definition, the I.D. of the same dash size legacy and modern hoses are identical. However, advances in materials science and process engineering enable a modern hose to have a smaller outside diameter (O.D.) than its legacy counterpart. This allows for more compact hose designs that can fit and route more easily on existing equipment. Furthermore, engineers are able to design hydraulic systems that require less space, which can reduce the overall machine size or free up valuable space to accommodate other components.

In the case of -16 size hose, a single modern hose has a 6.6 percent smaller O.D. and a 12.9 percent smaller cross-sectional area than a legacy -16 SAE 100R2 hose **(figure 2A).** The smaller cross section of modern hoses means they require less space in a hose-cable track—freeing space for additional hoses or lines in the existing track or enabling smaller track designs for weight and space savings. **Figure 2B** compares the 11.7 percent track area savings for three -16 size hoses with 2 mm clearances between components.

To demonstrate the application advantages and engineering performance improvements of today's advanced hydraulic hoses, the following examples show how a "modern" -16 size single-wire braided hose compares to a "legacy" -16 SAE J517 100R2 specification hose.



Easier fitting and routing

Systems require less space

Frees up space for additional lines

-16 SIZE HOSE	100R2	MODERN	DIFFERENCE	REDUCTION
O.D. (mm)	37.6	35.1	-2.5	-7%
CROSS SECTIONAL HOSE AREA	1,110	968	-143	-13%
TRACK AREA (mm)	5,148	4,545	-603	-12%
CIRCUMFERENCE - CLAMPING	118.1	110.3	-7.9	-7%

figure 2A

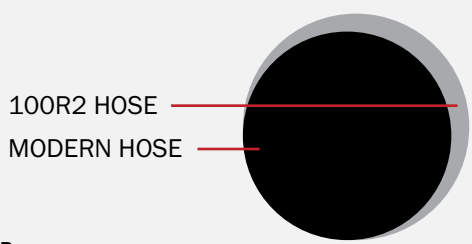


figure 2B

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MINIMUM BEND RADIUS (MBR) – HOSE ROUTING AREA AND PRESSURE DROP

The advanced materials design of modern hoses improves flexibility, which allows for a much tighter minimum bend radius (MBR) in a hose. In the -16 size hoses test, the modern hose's MBR of 152 mm is half the 302 mm MBR required for the 100R2 hose. The smaller MBR allows engineers to use shorter hose routings and provides greater design flexibility for placing other components such as pumps, valves, and cylinders to achieve more-compact overall designs.

Due to the smaller MBR of a modern hose, the 1550 mm hose routing length required for an application using -16 100R2 hose can be reduced by 72 percent to just 425 mm with the modern -16 hose. Moreover, comparing the square routing area and cubic volume (using hose diameter) shows a more than 70 percent savings in space required to fit the modern hose, compared to the legacy 100R2 hose **(figures 3A and 3B)**.

In addition, shorter hose lengths help reduce pressure drop and increase fluid flow. Computer modeling of modern -16 hose routing demonstrates over 50 percent less pressure drop compared to the -16 100R2 hose. Improved flow rate creates less pressure drop and heat generation, resulting in improved system performance. This enables designers to reengineer hydraulic pumps and other components for additional system savings **(figure 4).**

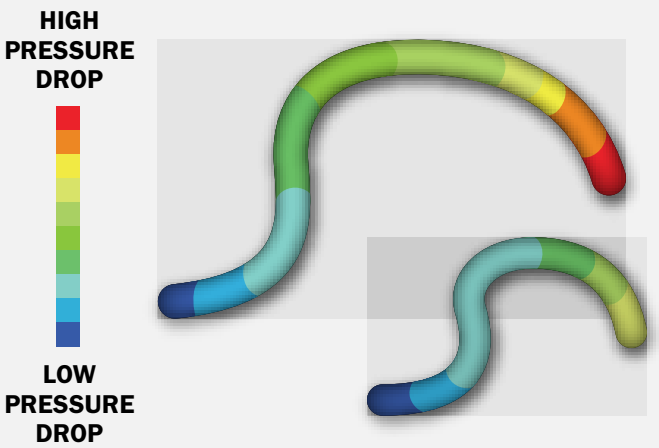


figure 3A

-16 SIZE HOSE	100R2	MODERN	DIFFERENCE	REDUCTION
MINIMUM BEND RADIUS (MM)	305	152	-153	-50%
HOSE CUT LENGTH (MM)	1550	425	-1125	-72%
HOSE ROUTING WIDTH (MM)	710	399	-311	-44%
HOSE ROUTING HEIGHT (MM)	990	526	-436	-47%
HOSE ROUTING AREA (M^2)	0.70	0.21	-0.49	-70%
HOSE ROUTING VOLUME (M^3)	0.026	0.007	-0.019	-72%
HOSE UNIT PRICE ($U.S.)	$0.10	$0.10		
HOSE PRICE ($U.S.)	$155.00	$42.46	-$112.54	-73%

figure 3B

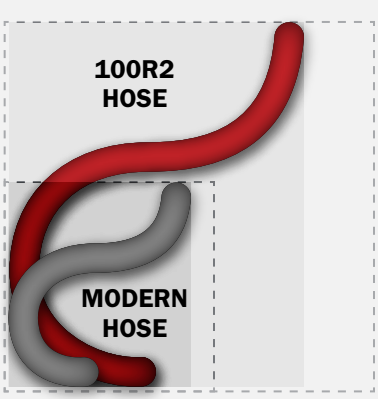


figure 4

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FORCE TO BEND – INSTALLATION, ERGONOMICS, AND SAFETY

Advanced materials, construction, and processes result in extremely flexible hoses that require much less force to bend them. The modern -16 hose in our comparison takes only 3.3 kg of force to bend (ftb) compared to the 10.3 kg of force required to bend a legacy -16 100R2 hose to the same diameter. This improved flexibility makes hose installation much easier and quicker, especially in compact hose routing designs. As a result, modern hoses can reduce replacement time—minimizing maintenance and downtime costs.

Timed installation trials show the modern hose taking 50 percent or less time to route than legacy hose. In addition, easier installation and better ergonomics also make it safer and less fatiguing for installers—reducing the risk for injuries.





Lower force to bend

Easier routing and installation

Faster assembly

Better ergonomics

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HOSE AND FLUID WEIGHT – LIGHTER SYSTEMS, FUEL ECONOMY, FLUID RESERVOIR, AND COOLING

Modern hoses are engineered to weigh significantly less than legacy hoses. In fact, the modern -16 hose in the comparison is 30.1 percent lighter weight than the same length of -16 100R2 hose. An immediate benefit of this is it makes moving, routing, transporting, and installing hose assemblies much less strenuous. OSHA recommends a single person lift a maximum of 23 kilograms. Considering that on assembly lines hoses are often grouped into kits, lighter modern hoses can negate the requirement for two people to lift hose kits for installation.

In addition to the direct reduction in per-unit hose weight, when combined with their tighter MBR requirements, using modern hoses in an application can also dramatically reduce the overall weight of the hydraulics. That is, not only does the modern hose itself weigh less than the legacy hose, but a shorter hose length can often be used, which also requires less hydraulic fluid—further reducing weight.

As demonstrated above with the hose routing example, the overall weight reduction benefits from using modern hose results in a 77 percent total weight savings from hose and fluid. When applied to multiple assemblies on one machine, the overall reduced hydraulic fluid volume may improve cooling and possibly allow a smaller fluid reservoir to be used, saving additional weight, space, and cost.

Plus, beyond the benefits to equipment users, lighter-weight modern hoses help equipment design engineers meet overall machine weight goals for shipping requirements, improved fuel economy **(figure 5).**



Less weight

Easier installation

Better ergonomics

Reduced equipment weight

-16 SIZE HOSE	100R2	MODERN	DIFFERENCE	REDUCTION
WEIGHT PER UNIT LENGTH (kg/100 meter)	143	100	-43	-30%
CUT LENGTH HOSE WEIGHT (kg)	2.22	0.42	-1.8	-81%
HYDRAULIC FLUID WEIGHT (kg)	15.1	3.6	-11.5	-76%
TOTAL WEIGHT (kg)	17.3	4.0	-13.3	-77%

figure 5

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IMPULSE CYCLES – DURABILITY AND REPLACEMENTS

The field performance of hydraulic hose assemblies can vary depending on actual fluids, pressures, temperatures, duty cycles, load spikes, abrasion, and other factors. Industry standards such as SAE J517 define laboratory impulse tests to aid in comparing the relative performance and durability of braided hydraulic hoses. These standards specify a minimum hose performance level of 200,000 impulse cycles. The advanced engineering of modern hoses delivers premium performance that has been tested to provide 600,000 impulse cycles or more—**3x the industry standard.** These products meet the performance requirements of today's demanding applications and provide the reliability to keep machines running and avoid downtime **(figure 6).**





Tested to 3x SAE impulse criteria

Longer lasting

Greater reliability

Improved uptime

-16 SIZE HOSE	100R2	MODERN	DIFFERENCE	REDUCTION
IMPULSE TEST (CYCLES)	200,000	600,000	400,000	-200%
NUMBER OF HOSE REPLACEMENTS FOR EACH MODERN HOSE	3	1		
ASSEMBLY PRICE (Hose $U.S. from Fig6A + $20 for couplings)	$175,000 (x3)	$62.46	-$112.54	-64%
INSTALLATION COST ($U.S.)	$2.00 (X3)	$1.00	-$1.00	-50%
DOWNTIME COST ($U.S.)	$1,000 (X3)	$1,000		
REPLACEMENT COST ($U.S.0	$3,531	$1,063	-$2,468	-70%

figure 6

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MULTIPLE ASSEMBLIES – OVERALL MACHINE SAVINGS

Combining the space, weight, flexibility, and durability improvements of modern hydraulic hoses can provide many potential design benefits to hydraulic engineers. The preceding examples demonstrate the potential benefits of using modern hose in a single hydraulic assembly. In large pieces of equipment that contain many hose assemblies, the benefits multiply. **Figure 7** shows the overall estimated savings potential when converting from legacy 100R2 hoses to modern hoses for a machine with 15 hose assemblies.

> It's an exciting time to be a part of the hydraulics industry. Advancements in materials and processing technologies are enabling hose performance that goes well beyond dated standards and delivers exceptional value to customers and system designers.

However, these values are only realized if the hose and coupling are designed to work together and are properly assembled. Innovations in hose design and crimper machines have come a long way and are providing the critical elements needed for integration. The benefits, including time, resource, and cost savings, will be realized across many industries where the quality of industrial equipment operations makes all the difference.



Increased integration

Improved uptime

Streamlined resource management

Greater cost savings

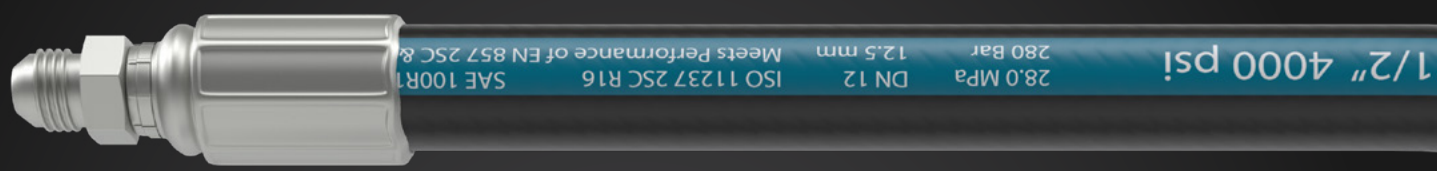
-16 SIZE HOSE	100R2	MODERN	DIFFERENCE	REDUCTION
NUMBER OF HOSE ASSEMBLIES PER MACHINE	15	15		
TOTAL HOSE CROSS SECTIONAL AREA (MM^2)	16,655	14,514	-2,141	-13%
TOTAL ROUTING AREA (M^2)	10.5	3.2	-7	-70%
TOTAL ROUTING VOLUME	0.4	0.1	-0.3	-72%
TOTAL WEIGHT OF HOSE/FLUID (kg)	23,250	6,368	-16,882	-73%
TOTAL REPLACEMENT COST ($U.S.)	$52,965	$15,952	-$37,013	-70%

figure 7

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RELENTLESS INNOVATION

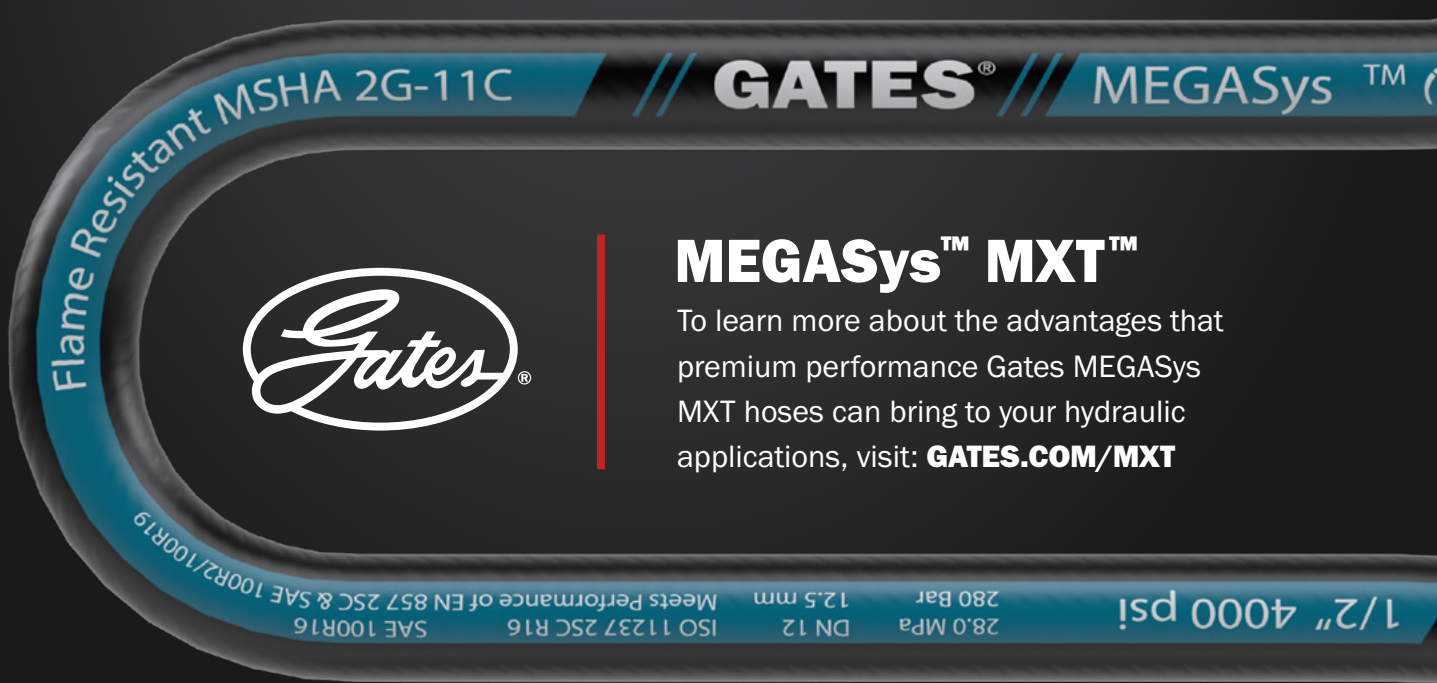
INSPIRED BY CUSTOMER CHALLENGES



Over the past 25 years, fluid power applications have become more complicated as power output requirements for equipment have increased. In addition, the available space for hydraulic assemblies has decreased as industry regulations, environmental considerations, and the introduction of additional systems compete for room. Meanwhile, the globalization of equipment platforms and complex supply chains have made the need for globally applicable solutions that meet a range of performance standards even more acute.

These types of evolving challenges are exactly what inspire Gates to apply leading-edge materials, fresh perspectives, and innovative techniques in pursuit of superior solutions for our customers. Setting new standards for modern fluid power systems, the Gates® MEGASys™ MXT™ family of hydraulic hoses are the latest example of Gates' commitment to innovation. MXT leverages breakthrough materials science and advanced process engineering to offer customers lighter, more flexible, more compact, and more universally applicable hydraulic hoses designed to address today's fluid power challenges and requirements.

Upgrading to modern hydraulic hoses offers businesses across the industry spectrum a wide range of business and operational benefits, including greater uptime, efficiency, and productivity; reduced costs and resource use; and improved health and safety.



MEGASys™ MXT™

To learn more about the advantages that premium performance Gates MEGASys MXT hoses can bring to your hydraulic applications, visit: **GATES.COM/MXT**