The world of railroading is about to witness a historic and rather poignant event. On Jan. 1, 2015, the most famous and popular locomotive diesel engine ever produced will likely cease to be built for the production of new locomotives destined for rail customers within the United States.

I’m speaking of the Electro-Motive two-cycle 567-, 645-, and 710-series prime movers. Approximately 50,000 locomotives were produced new for the U.S. market with these engines, and many more export models were built for customers around the world, making it the most popular locomotive engine of all time.

The brilliant yet simple design of this engine, combined with its ruggedness and reliability, propelled it to this lofty position. From a design concept in the 1930s, the architecture changed little for generations of production in the LaGrange, Ill., plant, headquarters for Electro-Motive Corp. The company later became the Electro-Motive Division of General Motors, and after its sale to an investor group, is known today as Electro-Motive Diesel, a division of Progress Rail and Caterpillar.

This speaks volumes for the original layout and design of the engine by General Motors research chief Charles F. Kettering and his design team. Originally developed in 1938 as a 567 (the number referring to cubic inches per cylinder), it underwent turbocharging in the 1950s, then grew to 645 status in 1965, and evolved into the 710 in 1984.

With each change, the engine grew in terms of horsepower and development. Its popularity with railroads, as well as in marine propulsion and stationary generator applications, was spurred on by an unprecedented ease of maintenance, durability, and reliability. As a matter of fact, most of these engines remain in service around the world today. As I write this, the company where I work still relies on a 75-year-old switcher in daily yard service.

Alas, ever-tightening exhaust emissions regulations have laid claim to the future of this exceptional engine. Although these engines were made notably cleaner with modifications to Tier 1 through 3 levels, Tier 4 apparently could not be achieved.

The engine will likely continue to be popular in other parts of the world, and in repower operations where the remanufactured, older locomotives will not be held to such demanding standards. The used locomotive market will see fresh activity as interest in rebuilding units arises as an alternative to unproven, more costly, and more maintenance-dependent new equipment.

Fortunately, and as a direct result of the engine's popularity and longevity, the familiar sound of a passing EMD will remain with us for a long time. Whether it be the shriek of a turbocharged SD40-2, or the whine of a GP9, there are enough of these veterans still out there to ensure that the greatest locomotive engine of all time will not fade quietly into the night.

BILL BADURSKI worked for EMD in the 1970s and 1980s as an instructor in its training center and served as a technical engineer in a 40-plus-year career in locomotives that is ongoing.

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Inside the wired locomotive

The unseen electronics behind today’s motive power

The basic look of today’s modern locomotive has been essentially unchanged for more than a quarter of a century, since the introduction of the comfort cab design in the late 1980s.

Predating this visual change by only a few years was the beginning of a massive evolution under the hood and in the cab to modernize the electrical systems that operate and control a locomotive. Electro-Motive Division’s 60 series and General Electric’s Dash 8 series both debuted in the early 1980s, introducing microprocessor control to their product lines.

Electronics since then have become better, faster, smaller, and cheaper, which has allowed the builders to increase the usage of computers and integrated electronics in almost every part of the locomotive. This also has allowed builders and railroads to eliminate extra equipment such as distributed power and end-of-train control units that typically were mounted on the top of control stands or elsewhere in the cab. Information from these devices has been placed into the main display screens on the locomotive’s control stand.

In the last two decades, a local area network, also known as LAN, has been employed inside new locomotives, allowing systems to easily talk to one another directly or via other systems connected to the network. A local area network is an interconnected network of cabling that connects various devices in a specific area. Builders briefly used fiber optics to create networks on locomotives, but eventually reverted back to copper wire. The network allows the locomotive to monitor thousands of parameters, feeding the information back to the necessary systems within the unit.

EMD’s FIRE (Functionally Integrated Railroad Electronics) screens and GE’s Smart Displays located in front of the engineer are actually self-contained computers and coordinate locomotive systems, support systems, and third-party equipment. A second display is added when additional equipment such as distributed power is installed to allow more information to be displayed simultaneously during operation. In the event of a failure of one of the displays, the information can be consolidated on one screen. Railroads have the option of placing display screens on the conductor’s desktop on the opposite side of the cab, which typically features a limited amount of control to certain features, with the remaining information presented in read-only format.

The increase in the last decade of wireless communication has enabled locomotives to keep in contact with the railroad or locomotive builder 24/7 if necessary. This connectivity allows a locomotive to report in real time alerts, failures, or other preset parameters.

Builder-installed systems such as EMD’s Intellitrain and GE’s RailConnect 360 Monitoring & Diagnostics primarily monitor the various aspects of the engine, control system, and related components. Third-party systems from companies such as Wi-Tronix,
IONX, Lat-Lon, MotivePower, and ZTR, can provide similar monitoring while also providing additional features that complement EMD's or GE's offerings.

These builder and third-party systems can monitor such things as fuel level, brake pipe pressure, throttle position, train location, engine state, train overspeed, impending dangerous weather in the direction of the train's movement, potential track issues, and wireless event recorder downloading. Access and notification to the railroad or builder is typically available in the form of Web access, smartphone apps, email, or text alerts. Many of the third-party systems can also be installed on older locomotives without microprocessor-based systems.

A form of "cruise control" has also been introduced within the last decade that can operate the train automatically across a territory. Information such as a train's loads, empties, length, and tonnage are entered into the computer and integrated with the track profile, speed limits, slow orders, etc., of the territory along with the destination to allow the train to operate itself in the most efficient manner possible as it moves across the line.

Intervention by the engineer is rarely needed when the train is operating on clear (green) signals. New York Air Brake's LEADER and GE's Trip Optimizer are two such systems in use today by railroads in North America.

With the upcoming implementation of positive train control, the equipment needed to operate PTC is adding another level of complexity to the existing electronics on a locomotive. As time goes on, new locomotives will certainly become more intelligent, allowing for greater productivity, utilization, and less downtime.

New leased power for East Penn

Kennett Square, Pa.-based East Penn Railroad is leasing two GP38-2s from GATX Locomotive Group. GMTX Nos. 2800 and 2801 are former WAMX (Watco) Nos. 3811 and 3812, and were repainted at Metro East Industries in East St. Louis, Ill. East Penn operates 114 miles in southeast Pennsylvania and Delaware. Mark Mautner
Keeping it cool

Big, high-horsepower locomotives generate a lot of power and a lot of heat. Radiators take care of it working order. Higher temperatures lower the viscosity (thickness) of oil, which increases the wear of internal components.

EMD utilizes a slightly different layout, with two separate loops from the engine, one for the radiator and oil cooler and another for the aftercooler. Various connections between the two loops allow the onboard computer to utilize excess cooling capacity in the aftercooler loop if needed.

The vast majority of locomotives on the road today utilize simple tap water for coolant in their radiator systems. Water is much more efficient at transferring heat than a mix of water and antifreeze that's typically found in your car's radiator system. Benefits of using water allow the overall size of the radiator system to be smaller due to its high-heat transfer performance. Water is much more efficient at transferring heat than a mix of water and antifreeze that's typically found in your car's radiator system. Benefits of using water allow the overall size of the radiator system to be smaller due to its high-heat transfer performance. Historically, high-temperature antifreeze was required, but lower-temperature antifreeze works well in locomotive radiator systems.
Layers of locomotive coatings

The fine art of wrapping 4,400-hp inside a metal jacket

The paint on a locomotive is an important visual feature of a railroad. From employees to the public, it's observed everywhere from trackside, on promotional material, and corporate websites. Paints' application, durability, and ability to protect the metal carbody from corrosion is important to railroads to ensure their locomotives are well protected from the elements while conveying the corporate image. Paint must also be able to withstand humidity, salt spray, and detergents used to clean a locomotive, as well as being stone and chip resistant.

Four paint manufacturers have the majority of the locomotive finishing business in North America. They are Axalta (formerly DuPont), PPG Industries, Sherwin-Williams, and Strathmore. Axalta's Imron line as well as PPG's Spectracron HSL paints and Sherwin Williams and Strathmore's lines of industrial coatings each have important roles in the market.

Locomotive builder Electro-Motive Diesel uses PPG on locomotives built at subsidiary Progress Rail's Muncie, Ind., and Bombardier's Sahagun, Mexico, plants while General Electric uses Axalta at its Erie, Pa., and Fort Worth, Texas, plants.

Railroads use qualification testing to ensure a particular brand of paint meets its standards for locomotive coatings. Environmental impact and performance are two of the most important factors when selecting paint. During the environmental portion of the review, a railroad looks for low VOCs, which are volatile organic compounds that are released as the paint dries. A railroad needs paint to perform well during application to achieve high throughput of locomotives through a paint shop.

Tightening environmental regulations at paint booths over the years and the cost to equip paint shops to comply have pushed several Class I railroads to close their own paint shops in favor of using one or more third-party shops. Class I railroads that still paint locomotives in-house tend to use a single paint manufacturer, while those that use third-party shops can have more than one paint manufacturer used on their fleet, depending on the shop that performed the work. Smaller shops have the ability to use whatever paint is requested by a customer, but they prefer to use a single manufacturer if possible. Painting is a personal endeavor and every paint acts differently when applied. A paint shop is most efficient when it uses the same material consistently, allowing employees to be their most productive.

Painting a locomotive is typically done in one of two ways. The majority of painted/repainted locomotives receive what is called a “base clear” paint job. This includes three layers of product: a primer, color, and clear coat. Less frequently applied is a “single stage” paint job which only uses the primer and color coat. This is typically done when cost is a factor and can occasionally be seen on lease and industrial locomotives.

While labor to paint or repaint a locomotive is the largest cost involved, quality paint, primer, and clear coat can be costly. High-quality materials can range from $40 to $200 dollars a gallon with a typical locomotive requiring 15-20 gallons of primer, 10-12 gallons of color, and 8-10 gallons of clear coat.

Ultraviolet radiation from the sun is damaging to a paint job over time. Many manufacturers incorporate one or more components to the clear coat to either absorb or reflect these rays. Additional UV protection is also incorporated into the color coat as well. Applied properly, a good paint job can last on a locomotive for a decade or more, ensuring the railroad’s corporate image looks its best.
Toiling away in the yards and on industrial spurs of Class I railroads are a small but important group of locomotives built several generations ago, the end-cab switcher. Once seen in almost every major yard and working back alleys spotting freight cars at customer's docks, their importance on a railroad's roster has diminished over the years.

Electro-Motive Division of General Motors had by far the most successful line of end-cab/offset-cab and center-cab switchers. The company built more than two dozen variants during a production period that spanned more than a half century. While all major builders constructed their own style of end-cab/offset-cab and center-cab switchers, hundreds of which still live on in shortline and industrial roles today, only EMD models survive in 2015 on the seven Class I railroads.

As the need for purpose-built switch engines waned in the 1960s and 1970s, railroads began to look for a more versatile locomotive that could perform both road and yard chores. Responding to that need, EMD constructed a variation to its successful 1,500-hp SW1500 switcher introduced in the 1960s called the SW1504. The SW1504 was essentially a SW1500 equipped with higher-speed Blomberg road-switcher trucks, but its design failed to attract the attention of U.S. railroads. Only one customer, Ferrocarriles Nacionales de México, bought it.

The final line of road-switchers EMD introduced in the early 1970s was the Multi-Purpose or MP line of switchers. This model used Blomberg trucks and had options for accessories such as a toilet to meet crew requirements for service outside of yards.

Sales of the MP line were modest in the 1970s and 1980s, with MP15DC, MP15AC, and MP15T production collectively failing to match the totals of other well-known EMD models such as the SW9, SW1200, and SW1500.

The main difference between the three MP models is the MP15DC uses a D.C. main generator while the MP15AC has an AR10 alternator. The MP15T uses an eight-cylinder, turbocharged engine instead of a 12-cylinder engine used in the A.C. and D.C. models.

Deregulation of U.S. railroads under the Staggers Act in 1980, however, killed the switcher manufacturing business. Under Staggers, freight railroads were permitted to radically overhaul their networks, operating procedures, and business model since they were now free of Interstate Commerce Commission supervision.

One of the resulting changes was downsizing of unprofitable operations with many branch lines and local operations either abandoned or sold off to lower-operating-cost short lines.

That created a surplus of low-horsepower locomotives, and GM’s EMD subsidiary assembled its last MP15ACs for freight railroads in October 1980 (four for the Katy and one for the Golden Triangle short line); several MP15ACs were delivered to U.S. government facilities and Canadian port operators in 1982 through August 1984 (when National Harbor Board No. 8406 was shipped from the London, Ontario, plant to the Montreal port operator). The final 34 MP15Ts were delivered to Seaboard System in late 1984 and 1985.

The last models produced by EMD continue to survive in sizeable numbers on Class I railroads, with the SW1500, MP15DC, MP15AC, and MP15T models most prevalent. Other than the standard maintenance cycles, most fleets are still in their as-built configuration.

Recently, several railroads have attempted to implement upgrades to their end-cab

A pair of Canadian Pacific MP15ACs work Muskego Yard in Milwaukee, Wis., when the railroad had more end-cab switchers. Today, CP is the only Class I with no end-cab switchers in revenue service, and their numbers on the big systems are dwindling. Chris Guss
switchers in an effort to extend their service life. But one eliminated them entirely.

Canadian Pacific is the only railroad to completely purge its end-cab switcher fleet from revenue service. The last MP15ACs were eliminated from the roster in late 2014, leaving only SW900 No. 6711. This unit is captive at CP's Ogden locomotive shops in Calgary, and used as a shop switcher and for positive-train-control testing.

Canadian National has embarked on a small overhaul program at its Homewood Shops, south of Chicago, on its remaining SW14 switchers. The SW14s were originally built for Illinois Central in the 1950s as EMD SW7s and SW9s. IC's Paducah, Ky., shop remanufactured them in the 1980s and designated them as SW14s. Canadian National still owns four and is rebuilding them for service in the Chicago area.

Union Pacific is underway with a program to upgrade its fleet of MP15ACs and MP15DCs, installing ZTR's Nexsys III-i control systems at its North Little Rock, Ark., shops. The control system is popular with UP, which is installing this in other locomotive models as well.

Norfolk Southern has been the most ambitious in terms of rebuilding its end-cab switcher fleet. The road's Altoona, Pa., and Roanoke, Va., shops began a rebuild program on the MP15DC fleet in 2011 that involves replacing the main generator with an AR10 alternator, adding alignment control couplers, and other upgrades.

NS also upgraded one MP15DC in 2011 with increased horsepower output. No. 2423 had its stock 1,500-hp 12-cylinder, 645E prime mover replaced with a turbocharged version of the same engine rated at 2,500-hp (later reduced to 2,100-hp). The radiator system was enlarged to support the increased cooling needed by the higher horsepower engine including an enlarged long hood with additional radiators and cooling fans. The unit, now designated a MP21E, also received the other upgrades found on other MP15E rebuilds described above.

With their ranks slowly diminishing, end-cab switchers will most likely always have a role on certain Class I rosters due to their smaller size and weight, but their days dominating yard and industrial service certainly peaked long ago.
Trends and the top dogs

The latest among the Super Seven Class I freight railroads’ rosters and their top locomotive buys

A railroad’s locomotive fleet is an ever-changing selection of power. Management is constantly evaluating new locomotive purchases, rebuilding existing power, and retiring older, less reliable units. New locomotive orders haven’t slowed despite the introduction of Tier 4 emissions technology and the temporary sidelining of EMD’s domestic production while its Tier 4 freight locomotive is prepared for rollout in 2017. In EMD’s absence, General Electric is busy building at its two shops in Erie, Pa., and Fort Worth, Texas. Here are highlights of recent activity on each Class I roster along with the top trending model on each.

BNSF Railway is well into its aggressive, multi-year plan of buying new power, focused on the unique A1A-trucked ES44C4. With traffic softening, this may spell the end for older road locomotives as the company renews its fleet. Expect to see BNSF step up its rebuilding of older A.C.-traction units and upgrading D.C.-traction locomotives to A.C. BNSF has also sent SD45-2s for rebuilding into 3GS21C six-axle gensets or SD40-2Rs with 16-cylinder engines. The railroad also continues its multi-year program to upgrade its fleet of GP35s with Dash 3 electronics, converting them to GP39-3Rs. Top model: GE ES44C4

Canadian National continues to make steady purchases of new GEs as it expands usage of distributed power and A.C. traction in an effort to haul more tonnage on existing train schedules across the system. CN’s shops are modifying and releasing secondhand locomotives the company purchased in recent years from various sources. Its semi-captive fleet of older second-generation locomotives in ore service on former Bessemer & Lake Erie and Missabe properties has begun to change with the first Illinois Central SD70s assigned to the B&LE this year. Top model: GE ES44AC

Canadian Pacific put new locomotive purchases on hold after the 2012 arrival of CEO Hunter Harrison and shows no signs of change on the horizon. Instead, CP seems satisfied to receive both four- and six-axle ECO rebuilds from EMD, with more SD30C-ECOs due in 2015. Top model: EMD GP20C-ECO

CSX Transportation skipped new locomotive deliveries in 2014, but now has an expected 200 new GEs arriving before December. Rebuilding in-house has shifted to four-axle locomotives, while six-axle rebuilding has moved to third-party companies. Top model: GE ES44AC

Kansas City Southern/Kansas City Southern de Mexico continues to buy new power from both GE and EMD. In 2015, the company is purchasing both GEs and EMDs that are restricted to Mexico because they are not Tier 4-certified. Older D.C. road locomotives continue to hold down secondary assignments. Top model: GE ES44AC

Norfolk Southern has met its power needs between rebuilding and purchasing new through the end of 2014, but plans only to rebuild this year, with no new power on the books for 2015. Major overhaul programs involving several locomotive models continue at back shops in Altoona, Pa., and Roanoke, Va. Top model: GE ES44AC

Union Pacific has long been a strong proponent of large orders of new power, and continues the trend in 2015 with 150 new GEs on order. Its 500-unit fleet of SD40-2s is cycling through the backshop in North Little Rock, Ark., as part of a multi-year program to renew these trustworthy locomotives. They are beginning to be seen in almost every part of the Union Pacific system now. UP has relocated the control stands in a number of GP60s and SD60s to a position more parallel to the cab wall, allowing for easier bi-directional operation when the units are in local service. UP calls the modified units GP62s and SD62s. Top model: GE ES44AC

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