

TUV makes a CE mark

For many years, the **LeTourneau** L-1800 was the largest front end loader in the world. Powered by a 2000-hp (1500-kW) V16 diesel engine that turns a 600-kW three-phase generator for driving the wheels, it also uses variable-speed electric motors at each wheel and can lift 100,000 lb (45,400 kg) with its bucket. After LeTourneau approached **TUV** Rheinland of North America to assist with CE marking of the loader, the first step was to determine what directives and standards applied to such a product.

Three directives were found to apply to CE marking: the 98/37/EC machinery directive concerned with mechanical and operator safety; the 73/23/EC low-voltage directive concerned with electrical safety; and the 89/336/EEC EMC directive concerned with electromagnetic compatibility. Because the project was undertaken before a pressure equipment directive was in force, it was not considered.

Two basic methods to show compliance are defined in Articles 10.1 and 10.2 of the EMC directive. Article 10.1 is the self-declaration method



LeTourneau and TUV worked together on the CE marking process for the L-1800 electric drive front end loader.



Because the loader has electric drive and drive-by-wire, susceptibility of the control systems to outside interference is of critical importance for safe operation.

and is usually used for small products that can be tested in a laboratory using harmonized standards. Article 10.2 defines a compliance method that uses a competent body to oversee the testing and certify the product. It is used in situations for which the standards cannot be followed. Because the size of the loader negated laboratory testing, Article 10.2 was selected to accommodate testing at LeTourneau's manufacturing facility.

EMC standards are separated into three groups. Basic standards have specific information on the EMC tests to be performed. Product-family standards are top-level protocols defining tests to be performed on common products like computers and household appliances. Generic standards are top-level rules that define the tests for products that do not have a product-family standard.

Choosing the EMC standards to be used for the LeTourneau project was straightforward. At the time the testing was conducted, no product-family standard existed for earthmoving equipment so generic standards EN 50082-2:1995 and EN 50081-2 were used, which have since been replaced by EN 61000-6-2 and EN 61000-6-4. Both immunity (susceptibility to outside interference) and emissions tests (interference generated by the product) are specified.

When determining the applicable standards for conformity, the priority is to see if there are EU harmonized product specific standards available. If such harmonized standards exist, and it can be proven that the product complies with the requirements specified within them, the EU authorities will assume conformity with the directives. In this case, there were standards for earthmoving machinery. Specifically, EN 474-1: Earthmoving Machinery-Safety, Part 1: General Requirements and EN 474-3: Earthmoving Machinery-Safety, Part 3: Requirements for Loaders were applicable. Product-specific standards such as these are adopted to provide the technical means for determining the conformity with the essential requirements for the specified directive.

Although these two standards covered the overall safety of the loader, there are still specific safety standards that are referred to in the text, which is not uncommon as it does not make sense to rewrite the specific technical requirements that already exist in recognized standard form. For the hydraulics system, EN 983: Fluid Power Systems-Hydraulics was applied; for the electrical system, EN 60204-1: Safety of Machinery-Electrical Equipment of Machines. The EN 60204-1 standard is recognized by both the machinery and low-voltage directives, and is therefore a valuable tool for CE marking of machine products with electrical circuitry.

The hydraulic system was first evaluated for good engineering design, with all selected components and assemblies found suitable for the application. Since the control components operated at 24-V dc, electrical conformity was not a key issue. It was then determined that the safety functions in EN 474 were in place, which included the assurance that hazards were avoided in the case of single component failures and/or loss of power or leakage. A review of the design and simulated faults confirmed compliance.

The electrical system was evaluated in accordance with the EN 60204-1 standard. This standard required that the components comply with IEC/EN standards. In some cases, this resulted in selecting alternate components than were currently in use.

Because the large size and height of the loader would require many points for emissions and immunity measurement, EMC tests were performed with the measuring antenna at both 2 and 4 m (6.5 and 13 ft) off the ground. Unfortunately, the loader needed to be operating with its wheels rotating during the emissions and immunity tests. To accommodate the tests, LeTourneau devised a way to raise the

entire 225-ton (204-t) machine off the ground and up on four very large steel columns.

Not unexpectedly, high broadband emissions were noted when the wheels were driven by the motor drives. Emissions were only slightly over the limits due to the fundamentally good design of the LeTourneau drive system. After consideration of where the loader would be used, it was determined that the essential requirements of the EMC directive would be met even though the emissions were above the limit. The loader would never be used outside of a large strip mine, likely to be miles from any populated areas. The immunity testing plan was modified from the standard.

For smaller products, testing would be performed over a wide range of frequencies in a laboratory using a shielded anechoic room so that the RF (radio frequency) immunity signals would not radiate into the environment. In the case of the LeTourneau loader, the size meant that the testing had to be done in an open test area, restricting the RF immunity test to legal radio operating frequencies.

This article was written for *SAE Off-Highway Engineering* by **Bruce Fagley**, Senior Specialist, EMC, and **Richard Grumski**, Area Manager, Mid-West Region, TÜV Rheinland of North America.

Aircraft towing made easier

Towing airliners quickly and safely at airports demands high levels of maneuverability and easy operation. The **Brevini** Group has produced a complete hydraulic drive and clamping system for a new **KraussMaffei** airport tow vehicle without the normal drawbar linkage. It is claimed to facilitate faster movement up to 30 km/h (19 mph), a tighter turning circle, and added maneuverability.



KraussMaffei's new aircraft tow vehicle uses Brevini technology designed to ease unpowered aircraft movement at airports.

The Brevini package includes planetary-gear pump drives, wheel drives, and piston motors. According to the company, the initial aim of the project was to produce a stronger truck design capable of towing the new generation of airplanes as well as older, larger aircraft such as the 747. The truck taxis the aircraft by ramping its leading wheel into the rear bay of the vehicle. For the front wheel of the airplane to load easily, Brevini CWD (compact wheel drive) hydraulic wheel drives are used to drive the rear wheels, removing the need for a single rear axle assembly.

The CWD units, acting as the hub of the wheels, use Brevini's compact planetary gearing to distribute the driving force throughout the gearbox. Once the aircraft is in place, it is secured via guides controlled by two hydraulic cylinders. These positioning cylinders and the wheel drives are powered independently using four pumps connected to a Brevini BZ pump drive, which is driven directly by the main diesel powerplant and again uses planetary gears to split the driving force four ways, allowing all four pumps to be powered by a single driveshaft.

Stuart Birch

Fuel tank weld quality checks

Off-highway vehicles are subjected to extreme conditions and stress loadings, including the effects on welds. In the UK, **Permoid Industries**, which has a continuous improvement program in place, has enhanced its welded fuel tank quality via changes to manufacturing procedures following advice from the welding research organization, **TWI**.

Permoid has an annual output of several thousand diesel fuel tanks for earthmoving vehicles to what it describes as "a demanding service specification." The company asked TWI to address two issues concerning tank corner tie-in welds and a failed drain plug. Permoid wanted to know if a manufacturing defect or service incidents were affecting performance of the welds, and it wanted to minimize any need for re-work.

A TWI engineer carried out a Joining Forces Product and Process Review. According to TWI, the review confirmed that despite the combination of robotic and semi-automatic welds in the same application, the corner weld quality was consistent and demonstrated good fusion and met the design requirements of the tank. TWI made recommendations on how to maintain this quality on each unit.

Investigation of the second issue—a failed drain plug—revealed that a crack propagated by fatigue from the toe of a fillet weld had caused a leak. TWI recommended that further information should be gathered about any other failures that may have occurred before deciding on any possible remedial action.

Stuart Birch

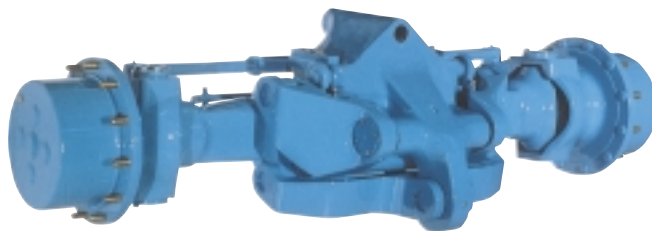
Dana grows for agricultural vehicles

Through leveraging industry experience and state-of-the-art design tools, **Dana Corp.** has tailored numerous specialized systems to fill specific needs of agriculture equipment. According to Bob Brazeau, Director of Engineering for Dana Spicer Off-Highway Products Division, "We help our customers meet the worldwide demand for affordable and reliable agricultural equipment with tough, application-specific axles, transmissions, and transaxles for low- to high-power tractors. We also supply specialty harvesting equipment and self-propelled combine drives."

Dana manufactures a variety of suspended axle systems for agricultural applications, all designed to improve vehicle stability. By helping to keep tires in contact with the ground, Dana axles improve equipment maneuverability as well as driver control and response times, claims the company. The suspended axles are said to provide for a smoother ride for increased operator comfort and reduce operator fatigue. Suspended axles tend to allow for greater vehicle speeds when traveling on-road from farm to farm, an important feature for vehicles that work smaller farms.

Dana is also currently developing a suspension module in which the wheels work independently of each other, providing for a smoother ride. The module will maximize ground interface for improved performance characteristics and increased tractive effort.

Dana has also been involved in providing components to agricultural vehicles to accommodate GPS technology, which offers increased driver accuracy, more efficient ground coverage, and more effective dispersal of seeds and chemicals. Dana's continuous-signal steering axle, which features a GPS sensor on the axle kingpin, is designed to be used with GPS control systems provided by OEMs.



Systems such as Dana's suspended axle for agricultural equipment are designed to increase operator comfort, improve workday efficiencies, and provide less negative impact to terrain and the working environment.

Dana is developing a central tire inflation (CTI) system for agricultural applications. Already in use for commercial and military truck applications, CTI technology was developed to increase traction, improve mobility, enhance safety, and increase throughput. CTI technology allows the operator to control tire pressure from within the cab to instantly accommodate the vehicle's working environment. Decreasing the tire pressure reduces compaction and improves traction by providing a larger footprint, while increasing the pressure reduces the footprint for greater efficiency during on-road travel.

CTI technology works through a simple, push-button operation and selectable pressure settings based on terrain and application. Benefits include higher speeds and greater maneuverability over a wide range of terrain; better handling in inclement conditions; and less impact on the working environment.

Jean L. Broge

Soil/machine interface research

A new off-road vehicle dynamics laboratory is being built in the UK by the **National Soil Resources Institute (NSRI)**. To optimize vehicle and equipment performance, the facility will help in the development of tires and traction systems that minimize soil compaction and improve soil-management techniques, according to Dick Godwin, NSRI's Head of Engineering. The NSRI's engineering center is part of **Cranfield University** and the new soil facility there is slated for completion next year.

Equipment planned for laboratory research includes two, whole-vehicle controlled moisture bins. One will be wide and shallow at 5 x 0.75 m (16 x 2.5 ft) and used for the evaluation of whole vehicles and tillage trains. The second will be a deep, narrow bin at 2.5 x 2.5 m (8 x 8 ft) to test a large range of components. The water level in the 45 m (148 ft) long bins can be controlled to simulate a range of off-highway conditions. What is described as a "sophisticated" single-wheel test system, designed to accurately control the torque or slip of a single test wheel in any environment, will measure tire performance and the effectiveness of different traction-control techniques. A variable-plane four-wheel traction plate can simulate undulating ground surfaces.

Godwin has announced a consultation phase regarding the new facility and has invited comment from, and discussion



A computer-generated image of the new Vehicle Dynamics Laboratory, which will be used to help develop tires and traction systems to minimize soil compaction.

with, companies in the industry. His long-term research aim is to create a virtual environment for the evaluation of any machine or vehicle configuration in a controlled manner, which will improve the accuracy, repeatability, and cost-effectiveness of tire and vehicle dynamics research for off-road vehicles and equipment.

Stuart Birch

FW Murphy eavesdrops on engines

One downside of electronically controlled engines is that when the engine begins to have trouble, it is harder to rely on old-fashioned eyes and ears to diagnose the problem. "Repairs" have become "troubleshooting," and malfunctions are hidden inside small black boxes. According to **FW Murphy**, its PowerView instrumentation allows operators to see what the engine is trying to say.

"It's important to have a display or interface between an operator and the equipment," said Chris Schutte, Off-Highway Market Manager, FW Murphy. "For unmanned applications, the machine can almost run itself now, leaving the operator somewhat disconnected. Now it's more an issue of monitoring what is happening. Having an accurate and reliable display is crucial."

PowerView and PowerView Analog Gages are the next generation of FW Murphy's MurphyLink product family for electronically controlled engines and equipment, communicating via the SAE J1939 CAN. The PowerView system is comprised of the PowerView display and analog gauges. The system is a multifunction tool that enables equipment

operators to view many different engine or transmission parameters and service codes. Information is displayed on a large graphical backlit LCD screen, providing a window into the modern electronic engines and transmissions. The brightness of the back lighting can be controlled via menu or external dimmer potentiometer.

The display can show either a single parameter or a quadrant display that includes four parameters simultaneously. Diagnostic capabilities include fault codes with text translation for the most common fault conditions.

The PowerView has four buttons that use touch-sensitive technology, which FW Murphy claims eliminates the possibility of push-button wear and failure. In addition, operators can navigate the display with ease. Enhanced indicators use ultra-bright alarm and shutdown LEDs (amber and red). The PowerView has a wide operating temperature range of -40 to 185°F (-40 to +85°C), displays operating temperature range of -40 to +167°F (-40 to +75°C), and environmental sealing to ±5 psi (±34 kPa). It also features **Deutsch** DT style connectors molded into the casing, plus it fits quickly and easily into existing 2 1/16 in (52 mm) diameter gauge openings.

The microprocessor-based Analog Gages are a series of intelligent gauges designed to display easy-to-read information transmitted by the PowerView. The gauges are offered in a selection of lens and bezel styles and colors, displaying critical engine data such as rpm, oil pressure, coolant temperature, and system voltage. They include features such as a smooth stepper motor operation for the 270° sweep pointer, an environmentally sealed case with two Deutsch DT style connectors molded into the casing, and green LED back lighting.

A combination audible alarm and relay unit is offered for warning and shutdown annunciation. The PowerView audible alarm fits the standard 2-in (50-mm) gauge panel opening and is used for warning and shutdown annunciation.

Jean L. Broge

PowerView instrumentation from FW Murphy includes a display that can show either a single parameter or a quadrant display that includes four parameters simultaneously.



On form for cab design

Tube-bending and end-forming specialist **AddisonMcKee** has created what it describes as a "highly innovative" tube-forming solution for French excavator cab manufacturer, **Buisard**. Traditionally, Buisard manufactured frame shapes for its small trench excavator in two halves, which involved the use of both a draw bender and a ring roller to form one half of the cab configuration, then necessitated complete re-tooling for the production of the opposite side of the cab frame prior to final welding. Instead, Buisard wanted cab frames to be made in one operation from a single length of tubular steel, not only to enhance productivity but also because this step would require minimal re-tooling to allow both right- and left-hand bends to be achieved on the same machine.

AddisonMcKee has extensive experience in the manufacture of tubular frames for agricultural cabs and large truck exhaust systems, but to meet Buisard's requirements a new tube-bending machine was necessary. Because Buisard would need to bend a range of product-specific bespoke steel sections that would differ for various cab types, AddisonMcKee elected to create a machine that embraced its electrically powered



French cab-manufacturer Buisard is using AddisonMcKee technology to make cab frames in one operation from a single length of tubular steel for enhanced productivity and minimal re-tooling.

Databend technology and offered multi-radius, multi-stack tooling for bending right- and left-hand components. The result is the DB100ESRBp, which incorporates multi-stack features to minimize tool-setting requirements.

With experience in push-bending technology, Addison-McKee incorporated a 3.5-m (11.5-ft) boost stroke system into a design capable of accommodating a maximum 8-m (26-ft) tube, a length necessary to facilitate the required one-piece cab construction. To provide repeatable control of the draw-bending process used for the cab and to provide consistent wall thickness at the point of bend, the new Buisard machine was equipped with AddisonMcKee's Synchro-Boost technology.

By precisely controlling the amount of tubular material drawn into any given bend, metals are able to be successfully manipulated into configurations that were previously

considered impossible, according to the company. With four complementary stack positions (two draw-bending, two push-bending), the machine has the capability to complete both right- and left-hand components in the same sequence, allowing, for example, a door aperture to be created on one side of the tubular frame and a window aperture on the other.

For the Buisard application, the DB100ESRBp machine will bend tube of a nominal diameter of 100 mm (4 in), maximum wall thickness of 2.5 mm (0.1 in), and maximum centerline radius of 250 mm (10 in). At its UK plant, AddisonMcKee produces a range of more than 50 basic hydraulic and electric computer-numerical-control machines that can bend a variety of pipes and tubes, from 4 to 273 mm (0.15 to 10.8 in).

Stuart Birch

High-strength steel for lightweight wheels

GKN Wheels, Corus, and SSAB Swedish Steel have developed a new design of off-highway wheel discs using high-strength steels (HSS) that are said to be "up to four times stronger" than regular mild steel. The design is believed by steel-maker Corus to be the first off-highway wheel disc to use HSS, claiming that it is "30% thinner and 30% lighter" than a conventional wheel disc and is also more cost-effective and environmentally friendly.

One of the major drivers behind the development of the new disc has been the increasing specification levels of agricultural, construction, and other off-highway vehicles over recent years, according to Corus. Manufacturers have made big advances in engine power, speed, and in-vehicle equipment to meet the increasing demands placed on these vehicles, while the supply chain has been subject to increased pressure to help reduce costs and weight.

GKN Wheels decided the biggest gains were not to be made by trying to take cost and weight out of existing

products but by "ensuring that it was not there in the first place." The company undertook a comparison benchmarking process, using a 12.5 mm (0.5 in) gauge wheel disc in grade 355 hot-rolled steel from its existing product range to assess whether high-strength steels could be used for a new wheel disc design. It was decided in principle that it could, so feasibility studies were carried out to see if GKN Wheels' existing cold-forming presses would be able to press an HSS component and to determine if a disc manufactured from higher strength, thinner gauge material—albeit to a revised design—would be able to resist the bending moments to which it would be subject. It was also necessary to discover whether it would have sufficient fatigue resistance to perform without risk of premature failure.

Using mathematical modeling techniques, SSAB was able to successfully validate the initial findings and the companies decided that it would be possible to down-gauge the disc from 12.5 to 8 mm (0.5 to 0.3 in) by substituting grade 550 hot-rolled steel for grade 355 material and by incorporating stiffening ribs into the design to provide the required levels of rigidity.

Cyclic fatigue tests were then carried out. For this step, plain discs were manufactured using existing tooling from 8-mm (0.3-in) material in grades 500 and 650. With this work successfully completed, pre-production tooling incorporating the stiffening ribs was commissioned and sample discs successfully produced from 8-mm (0.3-in) hot-rolled material in grades 500, 550, 600, and 650.

According to GKN Wheels' Director, David Eastham, the company is now looking to engage the support of the remaining members of the supply chain to realize the true potential of the project and bring the new disc into full production.

Stuart Birch

GKN Wheels, Corus, and SSAB Swedish Steel used high-strength steel to produce this prototype of a new off-highway wheel disc.



Video, radar aid safety

New safety aid technology suitable for construction vehicles and large trucks has been developed by **Cambridge Consultants** Ltd. (CCL). It has integrated a video link with its CCL-Softcar anti-collision radar technology to create a new platform for building safety aids. The system covers a 180° monitoring zone of 5-m (16-ft) depth and is said to offer "major advantages" compared to a simple video link, which some vehicles use.

With conventional cab video, it is difficult to present an undistorted picture and hard for the driver to determine exactly where and what objects are—especially when contrast is poor, according to CCL. Radar sensing overcomes this drawback, providing highly accurate detection of obstacle distance and trajectory.

In the CCL-Softcar application, a camera augments the radar by automatically directing the driver's attention towards

the most dangerous obstacle. The feedback provides the driver with both an accurate audio-visual warning from the radar, and an overlaid video image flagging the danger point, which could be the nearest object, the fastest-moving object, or the nearest pedestrian.

The system could also have a prioritized sequence of dangers. By further processing radar data using an object classification algorithm—the subject of current development efforts by a number of automobile manufacturers—the system is capable of providing what CCL terms “highly intelligent alerts.” While the radar can determine which obstacles are closest or threaten the earliest impact, for example, the camera system is better able to distinguish a pedestrian from a lamppost. The system’s ability to track/predict obstacle trajectory adds a further dimension to the anti-collision capabilities.



CCL-Softcar, here demonstrated on a car, is also applicable to off-highway vehicles used for construction.

CCL-Softcar is based on novel, low-frequency radar technology, which lowers the cost of the components required to build a system compared with alternative approaches, according to CCL. The video system is used to process images of that part of the view containing the most dangerous obstacle, greatly reducing the computing required and allowing the computer element of the safety system to be implemented using a low-cost, digital-signal-processing chip.

CCL-Softcar is a pulsed radar system working in the 5.8-GHz band, instead of the 24- or 77-GHz bands typically used in alternative anti-collision radar approaches.

Stuart Birch