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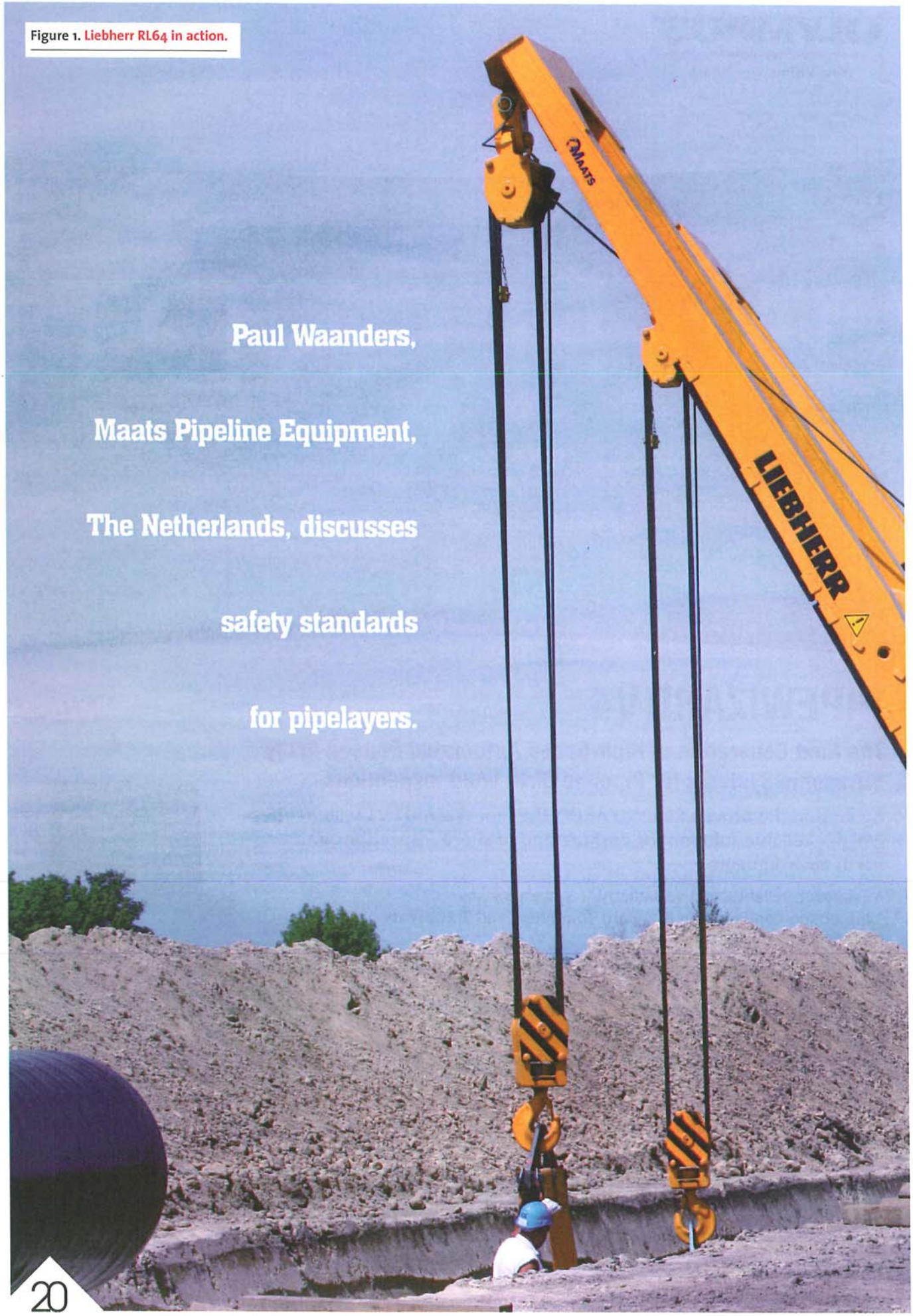
Figure 1. Liebherr RL64 in action.



Paul Waanders, Maats Pipeline Equipment, The Netherlands, discusses safety standards for pipelayers.

SAFETY AS STANDARD

Being relatively new to the heavy equipment used for pipeline construction, it struck me that legislation for common machinery such as pipelayers, and especially for safety aspects, is hard to find. The pipelayer is a derived machine, but its functionality is very different from the dozer it is based on and, although common pipelayers can hold up to 90 t, it is very different from any crane or crane-like machinery available. Despite ever-stricter safety regulations on pipeline projects around the world, there is no specific legislation available; there is no unambiguous standard that describes the features mandatory for ensuring the safety of operators of pipelayers. The result is that on many pipeline projects around the world, operators are protected by little more then their safety shoes and hard hats.

Of course, pipelayer manufacturers have to comply with common legislation such as the 97/68/EC, 2004/26/EC for engine emissions and they perform their measuring for noise emission according to (for example) ISO 6396:2008 and 2000/14/EC. To some extent, these standards do have a direct relation to the safety and well-being of machine operators, however they focus on specific elements and do not give a general safety guideline for the design of the

Figure 2. ROPS structure.

Figure 3. Fully enclosed cabin with 15° turned seat.

machinery. For Europe, there is the Directive 2006/42/EC that describes the 'essential health and safety requirements relating to the design and construction of machinery', a more general standard that applies to machinery placed on the market and/or put into service, at least for the EU.

Liebherr and Maats have assessed the basic hazards specific to the operation of a pipelayer. With its initial design, some years ago, Liebherr already chose some distinctive features that result in a safer environment for the operator. With today's ever-stricter regulations, it was time to check if any changes or improvements are required. Being the only specific safety-related standard available, the Directive 2006/42/EC was chosen as a guideline for the assessment of safety features for pipeline equipment. From this directive, there are a number of safety features that can be found mandatory for pipelayers and welding tractors.

Risks

The main risk when operating a pipelayer is tipping over as a result of too heavy or unbalanced loads, often in combination with soft or uneven terrain.

Another risk is faulty operation as a result of the complexity of operation of the machine. Sometimes, the number of handles and buttons need time to get accustomed to, and leave little time to react in case of an emergency.

A third risk is the lack of concentration of the operator resulting in faulty operation of the machine. Operators often are exposed to cold, heat, snow or rain. These factors have a distinct effect on the well-being and concentration of the operator and can therefore affect the safe operation of the equipment.

Based on the above assessed risks, Liebherr and Maats developed the following solutions.

ROPS structure

There are a number of standards that refer to a ROPS for heavy machinery:

- European Standard EN 474-1:2006, paragraph 5.3.3.1: Roll-over protective structures (ROPS). "Earth-moving Machinery shall be equipped with a roll-over protective structure (ROPS). The ROPS shall comply with EN 13510:2000."
- European Standard EN 474-1:2006, paragraph 5.3.3.2: ROPS for derivative machinery. "For derivative machinery, the ROPS shall be designed taking into account the operating mass (see ISO 6016:1998) of the derivative machinery in the heaviest configuration as specified by the manufacturer."
- European Standard EN 474-9:2006, paragraph 5.2.5: Operator's protection. "EN 474-1:2006, 5.3.3 does not apply for pipelayers."

This would mean that a ROPS is not mandatory for pipelayers. The directive 2006/42/EC, however, states the following:

3.4.3. *Roll-over and tip-over.*

"Where, in the case of self-propelled machinery with a ride-on driver, operator(s) or other person(s), there is a risk of rolling or tipping over, the machinery must be fitted with an appropriate protective structure, unless this increases the risk. This structure must be such that in the event of rolling or tipping over it affords the ride-on person(s) an adequate deflection-limiting volume. In order to verify that the structure complies with the requirement laid down in the second paragraph, the manufacturer or his authorised representative must, for each type of structure concerned, perform appropriate tests or have such tests performed.

Based on this paragraph, a ROPS construction should be in place on a pipelayer. Where, in the case of Liebherr, this used to be either a canopy (OROPS) or an enclosed cabin with a ROPS construction, Liebherr now decided to supply all its new pipelayers with enclosed ROPS cabins as a standard. Only the Liebherr welding tractors are still available with OROPS, as these machines are less likely to tip over.

Because mounting a cabin might be difficult on older machines, the roll bar is an option as an aftermarket product. On new machines, however, the enclosed cabin is the absolute safest solution, adding relatively little to the price of a new pipelayer.

In order to comply with the paragraph 3.4.3., Liebherr chose the ISO 3471 "Earth-moving machinery - Roll-over protective structures - Laboratory test and performance requirements (ISO 3471:2008, IDT)" as the standard to comply with.

Boom with hydraulic cylinder

In addition to the ROPS, Liebherr decided to use a hydraulic cylinder instead of a winch for operation of the boom. Besides the fact that this cylinder provides very accurate operation of the boom (especially useful when the machine is used with a bending machine or a welding crew), this boom is designed to hold the weight of the machine in case the machine tips over towards the load side. An additional advantage is the elimination of the risk of an overpull of the boom with the boom winch.

Safe Load Indicator (SLI)

More and more principals around Europe are asking for a safe load indicator on pipelayers. Although the pipelayer is not a crane as such, principals see the SLI as an aid to prevent accidents with machines as a result of too heavy loads. Reference is made to the Directive 2006/42/EC that states:

4.2.2. Loading control.

"Machinery with a maximum working load of not less than 1000 kg or an overturning moment of not less than 40 000 Nm must be fitted with devices to warn the driver and prevent dangerous movements in the event of: overloading, either as a result of the

Figure 4. Boom with hydraulic cylinder.

maximum working load or the maximum working moment due to the load being exceeded; or of the overturning moment being exceeded".

To help the operator to determine the actual loading of the machine and to avoid tipping over in the first place, Liebherr and Maats developed a Safe Load Indicator (SLI). The SLI informs the pipelayer operator continuously about the loading of the machine, regardless of the position of the equipment. If the machine reaches its maximum load limit, the SLI will recognise this and, depending on the setting of the SLI, will give a signal and/or limit the functionality of the machine.

The operator has the possibility to switch between three different settings: the SLI switched off; the SLI operating as a load indicator only; and the SLI operating as load indicator with automatic load limiter.

When the machine is loaded within a certain range of its maximum capacity (according to ISO 8813), the operator is informed accordingly. This system has both a visual and an acoustic signal inside the cabin. A visual and acoustic signal on the outside of the cabin is optional.

Fully enclosed cabin

A further reason to choose a fully enclosed cabin (apart from the ROPS) is to create a comfortable environment for the operator. Cabins are provided with a heater as standard and with optional air conditioning. Furthermore, all cabins are equipped with positive pressure ventilation to keep dust out. All this keeps the operator comfortable and helps him concentrate on the job at hand. To further add to the well-being of the operator, Liebherr has turned the operator's seat 15° towards the load side. This means that operators have a better view of the job at hand, with less stress on neck, shoulders and higher back.

Figure 5. Single joystick operation.

Single joystick operation

All basic functions can be controlled with two joysticks: one that controls the travel of the machine and one that controls both the boom and the hook. Liebherr was the first to use joysticks for pipelayer and welding tractor operation. These provide an intuitive way of operating the machine easy and precise. Releasing the travel joystick will result in immediate cut-off of power to the tracks. As the hydrostatic drive of the Liebherr machine does not need mechanical brakes, there is no necessity to operate them in case of emergency!

Hydrostatic drive

The hydrostatic drive line has a long tradition in the history of the Liebherr company. As the only manufacturer, Liebherr also offers this modern drive concept on pipelayers. The self lock of this system eliminates the need of a service brake, which could wear down. Moreover, a hydrostatic drive line does not need special mountain brakes, often used when machines have to operate on steep slopes. An emergency button on the dashboard cuts-off power to the tracks completely. The operation hydraulics (boom, hook and counterweight) stops automatically when the operator releases the joystick.

Another advantage of the hydrostatic drive is the lack of gears, there is a constant smooth build-up of power and speed, making it much easier for an operator to stay in control of the load.

Free fall device

The hydraulic winch that operates the hook is fitted with a free fall device. This is operated by a single push of a button on the joystick that operates the hook.

Conclusion

This assessment of risks has resulted in additional safety measures, not for Liebherr but for Maats. Although Maats has mainly Liebherr machines in its rental fleet, with all safety features as described above, it has been decided that the remaining non-Liebherr pipelayers in the rental fleet will be equipped with ROPS. The ROPS should be suitable for tests according to the EN 13510:2000 and ISO 3471:2006. Complying with these standards means that Maats can supply the ROPS structure with a CE certificate. WP