



**Construction Plant-hire Association**  
Shoring Technology Interest Group  
***Shoring Technical Information Note***



**TIN 208**

**Safe Use of Excavator Mounted Vibrators**

**1.0 Scope**

This document deals with excavator mounted vibratory pile drivers (EMV's) used to drive and extract sheet piling, trench sheeting, pile cages, plastic piling, mandrels and driving caps. Compared to traditional piling and rig based methods; the length of pile driven is relatively short, generally 6 metres or less - typically limited by the reach of the excavator.

EMV's are available in different shapes and sizes to accommodate different types of piles and excavator sizes. This document only covers those designed to be suspended from a single neck pin, not side driving or leader mounted designs and are applicable to the following commonly found makes and models in the UK:

<b><i>Make</i></b>	<b><i>Model</i></b>				
DCP	EMV70	EMV300	EMV450	EMV550	-
EMS	ESF03	ESF1	ESF2	ESF3	ESF4
ICE	230B	328B	428B	625B	823B
Muller	MS1	MS2	MS3	MS4	-
Ozkanlar OMS	S-40	S50	S60	S70	S80

The scope of this document does not include "swan neck" dipper extensions and is also limited to the supply via Non-Operated Hire; whereby the owner of the equipment has no control the equipment use. Owner operators may seek alternative guidance directly from the manufacturers.

**2.0 EMV Damage to Trench Sheets**

EMVs can easily damage trench sheets (especially long and/or thin sheets). The damage is most often located where the EMV clamps the top of the sheet, where the handling holes are located.

EMV's typically exert a 30 tonne to 50 tonne high frequency clamping force onto a very small area of the sheet. It is often difficult to drive the sheets vertically (inducing high bending moments during installation) and EMV's are generally not suitable for use in dense or cohesive soils where prolonged driving can cause fatigue related failures in the sheets.

STIG members should carefully inspect the tops of trench sheets for signs of EMV damage (e.g., crimping, buckling, bending, notching). If any damage is observed (especially around the handling holes) then the sheet must be cut down beyond the area of damage and new handling holes drilled.

It should be borne in mind that higher grades of steel are more prone to damage.

**3.0 Basic Safety Points**

All pile driving equipment is potentially self-destructive; abusive and inappropriate use will accelerate such damage and wear. Just because this type of equipment is capable of a task, does not mean that it was intended or designed for that task. To use this equipment for anything other than the tasks for which it was intended is dangerous and should not be undertaken. Piling vibrators are designed to drive and extract sheet piling, trench sheeting, pile cages, plastic piling, mandrels and driving caps. If in doubt about the suitability of the equipment for a specific task outside this definition the owner of the equipment or the manufacturer should be consulted.



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**3.1 Examples of inappropriate use**

- a. Using the piling clamp of the vibrator as a retractable sling location is very dangerous. This entails the machine operator opening the clamp, a site operative sliding over the sling and the machine operator closing the clamp, to hold the sling. Poor communication and subsequent crush injuries are the obvious concerns here;
- b. Using the piling vibrator as a grab, to lift and carry objects, such as sheet piling, across site;
- c. Using the vibrator as an impact hammer, by hammering with an open clamp;
- d. Using the vibrator in any plane other than vertical;
- e. Driving excessively long and heavy piles that exceed the limits of the equipment;
- f. Extracting piles installed using much larger, more powerful pile driving equipment can lead to serious damage to an EMV unit, with damage to elastomers and to the clamp very likely;
- g. Using the piling vibrator for excessive periods on refusal (see notes below on limit conditions).

**3.2 Guidance for use**

- a. There should be visual contact between the operator and slinger (spotter) at all times;
- b. Monitor the piling operation constantly and stop the process immediately if a dangerous situation arises;
- c. Consider excavator stability at all times as unlike piling rigs excavators seldom operate from a purpose built working platform;
- d. The equipment should be checked for defects every day and before putting into service. The frequency of checks should increase as the task become more difficult;
- e. This equipment must be used only by competent operators with relevant experience;
- f. Enforce an exclusion zone around the hammer when in movement or in use, never allow anyone underneath the EMV;
- g. Check the condition of any associated lifting accessories and ensure that the rated capacity of all lifting accessories and equipment are adequate;
- h. The working area should be adequately illuminated;
- i. The EMV can become hot during operation, and do not touch unless wearing appropriate protective clothing or after allowing the EMV to cool.

**4.0 Responsibilities**

The owner/supplier of the equipment is responsible for the provision of equipment in good condition, suited to the task (based upon information provided by the Hirer) and to provide suitable information on typical hazards associated with the plant being supplied (but not in relation to the detail of the site and operation where it will be used)

The hire of non-operated plant is often viewed as a means of securing plant at less cost, however this carries more responsibilities for the Hirer. The hire rate covers the use of the equipment, and the repair of breakdowns occurring as a result of wear and tear (not abuse or neglect). The rate does not cover basic checks and maintenance, as this is the Hirer's responsibility. These are outlined below and specifically within the operating instructions provided by the owner/supplier/manufacturer.

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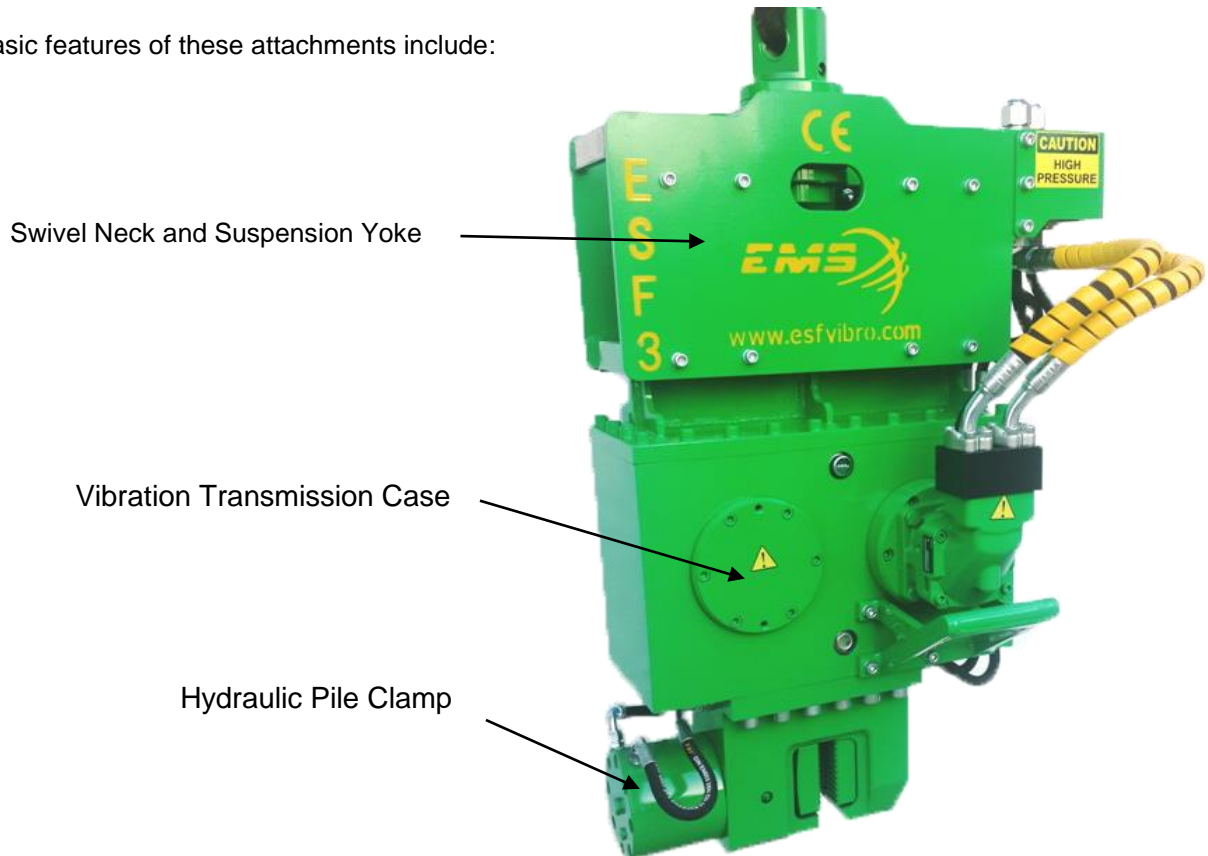
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**4.1 Key responsibilities of the Hirer**

- a. To provide a trained and competent person to operate the equipment safely and within its limits;
- b. Ensuring that the equipment is used safely in accordance with the operating instructions and not abused;
- c. Carrying out pre-use, daily, weekly checks on the equipment as detailed in the operating instructions, and outlined in this document. This allows monitoring the condition of the equipment to ensure that it is, and remains in, a condition in which it is safe to use;
- d. Ensuring all nuts, bolts, hoses and connections are tight. The vibrations produced by the pile driver, will always tend to loosen couplings and fasteners. The Hirer should therefore ensure that the operator is equipped and competent to tighten nuts, cap screws etc. Where the owners' representative has to return to site to tighten fittings on hoses or the unit – this is likely to be chargeable to the Hirer;
- e. Keeping all accessory items in good condition.

**5.0 Component Identification**

The basic features of these attachments include:





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**6.0 Fitting the EMV to the Excavator**

EMVs should only be fitted by those trained and competent to do so. The owner may supply a trained service technician to make the necessary connections.

**6.1 Electrical connection**

The vast majority of EMVs are fully hydraulic and so require no electrical connections. Those that require a connection to the excavators' battery may be configured for 12V or 24V.

**6.2 Hydraulic connection**

All EMVs have three hoses that need fitting to the excavator, Pressure (P), Return (T) and a Drain (D). The P and T Lines need to be reversible (bidirectional) to enable the proper clamp function of the EMV. These hoses should preferably be fastened using threaded or flange fittings rather than quick release fittings. Whilst quick release fittings are a major time saving device on site, reducing leakage of oil from hoses when the attachment is removed or reconnected, when used in conjunction with piling vibrators, they can prematurely fail and cause pressure issues.

Where quick release fittings are supplied at the request of the Hirer to facilitate repeated connection and disconnection, they must be limited to use on the P & T hoses. Any use of quick release fittings on a drain line can create back pressure, damaging motor seals and voiding warranties.

Historically, to ensure reversible P & T lines, hoses were connected to the bucket ram hoses, however with the increased use of quick hitches, it is more standard to fit to an auxiliary circuit. Likewise the drain line can be fitted to an auxiliary return line, so long as it has an unrestricted route back to tank (no back pressure); and clearly if not already used for the P or T lines. In the event that no additional auxiliary line is available there are a number of locations that the drain can be connected to including: redundant or surplus valve ports, teeing into existing drains (such as a slew drain), via main valve manifold using a tee or simply using a modified tank plate.

**6.3 Mechanical connection**

EMVs are designed to be mounted directly to the dipper, and via two separate single pin linkages creating pivot points. This design does reduce positioning control, when compared to such attachments as excavator mounted compactors used as pile drivers; but this is deliberate and inhibits the application of moments which would result in equipment damage. It is important that the shear pin is properly bushed to prevent wear on the bracket.

**6.4 Quick Hitches**

A quick hitch is a device designed to facilitate the fast interchange of attachments on an excavator. The connection of a quick hitch, a device designed to remotely release, to a piling vibrator, a device designed to produce high levels of vibration, will never be as safe as a direct connection of the piling vibrator to the excavator. The key issue here is the unexpected release of the attachment.

It is also known that quick hitches can be used to apply additional push (levering) forces on to the attachment. Damage may not be instantaneous, but such use has shown to damage the swivel neck, elastomers and clamp which may result in breakage or unexpected release of the attachment, or components of that attachment.

One problem with EMVs is the maximum height of the pile that can be driven, due to the limit of the excavator's reach. Stretching to drive long piles, can damage the piling vibrator, pile and potentially the excavator. Quick hitch use further reduces the available height for sheet piling, increasing the chance of inappropriate loading of the attachment.

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**6.4 Quick Hitches (continued)**

However, with the high prevalence of quick hitch use, it would be unrealistic to expect Hirers not to use quick hitches with EMVs. Although quick hitch removal is not without risk this is one application where market forces have determined the need for a solution. The vast majority of site problems occur as a result on some action attempting to save time. Quick hitches are one such area, where the time saving is clear, but the safety in use is compromised.

The Strategic Forum for Construction guidance on *Safe Use of Quick Hitches on Excavators*, published by the CPA, recommends that the attachment of piling and other equipment to a quick hitch is via a bespoke adaptor bracket, such as the one shown in the photos below. Please also note that, it is now becoming more common for certified lifting points to be added to this location. This eliminates the need to use the clamp to lift piles. The use, inspection and thorough examination of such lifting points fall under the requirements of LOLER.



**It is essential that attachments are always fitted to both jaws of a quick hitch.  
 Attachments must never be attached to the quick hitch by a single pin**

**7.0 Limit Conditions**

As with all machinery there are specific operational limits for EMVs. In the most basic sense this may be where the installation of a pile is taking far too long or cannot be driven at all. When the pile effectively stops moving a condition of “refusal” has been reached. Using an EMV beyond refusal is damaging to the equipment and can lead to breakages and danger. The most common symptom with vibratory equipment is that it gets very hot, the effect of this being leakage and reduction of the life of seals, hoses and bearings.



**7.0 Limit Conditions (continued)**

The Piling Handbook (see **13.0**) provides information on the generic suitability of vibration piling with regard to ground conditions, e.g. Vibration is not suitable for use in cohesive soils with a Cu value of over 45 kN/sq.m. For granular soils, EMVs are not generally suitable for soils with Standard Penetration Test N value above 30, although some penetration can be possible in soils with an N value of up to 50. This would depend greatly on the power of the vibrator, and of course the ability of the trench sheet to withstand such forces.

When refusal is reached the options are to either use a more powerful vibrator, change to an impact hammer or pre-auger to loosen the ground. For vibratory driving the Shoring Technology Interest Group defines these limit conditions for REFUSAL and REBOUND as follows:-

**7.1 Refusal**

Under normal predictable and reproducible conditions, refusal is defined to be where the penetration rate (time count) exceeds 5 minutes per 0.25m. The penetration distance of 0.25m is absolute, i.e. No conversion is allowed to, for instance, 60 minutes per 1 metre penetration.

**7.2 Rebound**

This occurs when a large portion of the hammer's energy is "bounced" back up into the pile as a result of force reflection at the pile tip, due to the pile hitting a nearly impenetrable layer or obstruction. The rebound forces will be transferred back into the hammer and the suppresser head; as a result the head will start "jumping" in relation to the vibratory case. In this situation driving should be stopped immediately or the hammer be retracted.

**8.0 Suitability of Work Equipment for a Given Location**

Piling equipment should only be operated and driven on firm ground with clear visibility of the working area. The hammer should be upright in the vertical plane at all times to avoid personal injury.

**8.1 Working near underground obstacles**

Before the start of any piling work the contractor should find out if there are any underground obstacles within the working area which could be dangerous to personnel. In the case of unforeseen contact or damage of an underground obstacle, work should be stopped immediately and the person in charge informed.

**8.2 Working near overhead power lines**

When piling near overhead power lines, the recommended safety distances should be maintained between the equipment and the overhead cables. When approaching overhead cables, pay attention to the movement of the hammer and its auxiliary equipment. In windy conditions the overhead cables will move, reducing the distance between the hammer and arcing may result.

Other precautions to avoid arcing could be:-

- shutting down the cable
- moving the cable
- covering (shrouding) the cable
- restricting the working area of the hammer

**NOTE:** Guidance on working near overhead line is given in HSE publication GS6 Avoiding danger from overhead power lines



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**8.3 Noise levels**

EMVs are marked with the sound power level during operation in accordance with the Outdoor Noise Directive. The effect of this sound power level will depend on the environment in which the EMV is operating and should be assessed in accordance with the *Control of Noise at Work Regulations 2005*. Tests conducted by the leading UK manufacturers DCP are summarised below.

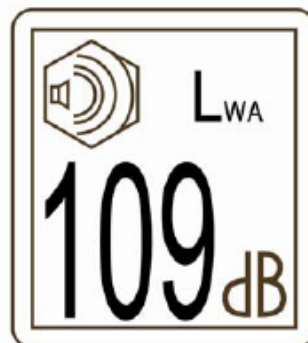
<i>Category</i>	Piling Equipment
<i>Base machine type</i>	NA
<i>Base machine serial number</i>	NA
<i>Vibrator Type</i>	<b>EMV300</b>
<i>Serial Number</i>	45-195

*Operating conditions during test in compliance with 2000/14/EC*

<i>Noise meter used</i>	Iso-tech slm-1353 integrating sound level meter
<i>Serial Number</i>	001004681

<i>Date of test</i>	6 <sup>th</sup> June 2008
<i>Location of test</i>	DCP works test area, Milton Keynes, England
<i>Ambient air temperature</i>	21°C
<i>Air pressure</i>	1020 hPa
<i>Wind velocity</i>	<1m/s
<i>Reference Parallelepiped dimension</i>	10.0m x 3.4m x 3.0m tall 1.0m

Sound Power Level





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**8.4 Working near buildings - Piling vibrations**

When carrying out piling operations with EMVs, an assessment of the potential effect of vibration should be carried out. All piling equipment which performs its function by production of impact or vibration, will introduce vibrations into the environment. Vibration monitors are available to hire from STIG member organisations.

Appropriate equipment should be selected for the location of piling operation. It is the Hirer's responsibility to ensure that the equipment hired is appropriate for the location. The equipment owner will be able to assist in the selection process if notified of site conditions and the nature of neighbouring buildings.

Consideration of the effects of vibration produced by piling equipment should include possible settlement as well as the physical shaking of a structure. Settlement of soils can create voids beneath structures such as foundations or utility lines. If you are planning on working near a live gas pipeline advice should be sought from those responsible for the pipes.

There are strict controls on the separation distance between gas pipelines and both excavation work and work that induces vibration in the ground. The utility must be contacted and alternative methods of installing e.g. excavation support may be required, or the pipeline may need to be isolated, disconnected or rerouted.

The following British Standards provide guidance on vibration related issues:

- BS 5228-2:2009+A1:2014 deals with control of vibration on construction sites in general;
- BS 6472-1:2008 gives guidance on the evaluation of human exposure to vibration in buildings from vibration sources other than blasting;
- BS 7385-2:1993 provides threshold values in excess of the previous two standards, relating to levels likely to cause structural damage in building structures;
- BS ISO 4866:2010 provides guidelines for the measurement of vibrations and evaluation of their effects on structures.

**9.0 Transporting the EMV**

When transporting the EMV it should be placed correctly in its transport stand. Once in place on the stand the jaws must be closed. The hydraulic hoses from the excavator should be released (the jaws will remain closed) and the hose ends capped to prevent contamination. The EMV should then be disconnected from the excavator.

**10.0 Transporting Piles on Site**

When first introduced nearly 20 years ago, it was clear that the methodology conceived for this equipment, included an element of lifting. However, this was clearly a lift from a localised stack to the position of piling works, so within the 15m exclusion zone stated. Unfortunately, it has become apparent that many sites take this too far, it has become fairly common practice to use the piling vibrator to not only lift a pile, but also to carry across site.

**NOTE:** All lifting operations require an appropriate level of planning and supervision, and must meet the requirements of LOLER wherever they are carried out.

The equipment is not designed for this, and this is one instance where capability exceeds the designer's intent. To prevent this unnecessary burden, a piling vibrator should not be used to lift or carry piles or other objects. Controlled pitching of piles, from a nearby stack is permissible through use of the lifting chain alone.





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**10.0 Transporting Piles on Site (continued)**

Exclusion zones should be created to minimise the risk of falling piles, however, if this is still an issue on site, alternative means of transporting and laying down sets of piles close to point of use, rather than in one storage area, should be used; and/or alternative lifting equipment or lifting points incorporated on quick hitches or EMV brackets should be used.

Where a sheet pile is lifted to vertical by a lifting chain this operation comes under LOLER as do the accessories involved. This means that thorough examination is required (6 monthly for accessories such as the lifting chain and shackles). A site specific lift plan drawn up by an appointed person is required and the piling gang supervisor will require lift supervisor training.

Where shorter, lighter piles are pitched using the EMV jaws clamped onto the pile and used to pitch it (or lay it down) without the use of a lifting chain, LOLER does not apply. (A safety chain fitted for this operation is not working as a lifting chain and is only there to restrain the pile if the jaws disconnect.). There is increasing preference by equipment designers, manufacturers and users for sheet piles to be lifted to the vertical by chain before the EMV jaws are engaged. In all instances the manufacturers' instruction manual should be followed.

**11.0 Installing Piles - Pitch & Drive**

Before starting the excavator all safety procedures and maintenance should have been carried out and a check made to ensure that it is safe to move the dipper arm. The transport stand should be released from the jaws of the vibrator. The vibrator should be manoeuvred above one end of the pile to be lifted, so that there is enough distance to allow safe insertion of the lifting chain through the eye of the pile.

The lifting chain should be inserted correctly (no twists, knots etc.) and secured with the chain clamp. Enough free chain length should be allowed for the pile to rotate to vertical during the lifting process without jamming against the underside of the clamp body. If this happens the chain will be overloaded, may subsequently break and allow the pile to fall - this is a severe hazard to all site personnel and must be avoided at all times.

Too much chain will allow the top of the pile to hang too far away from the clamp when it is raised to the vertical, which will make it difficult to engage the pile in the clamp. All personnel standing in the working area should be excluded before raising the pile until it just touches the ground. The pile will then be lifted to its driven location, and then and only then, should the EMV should be lowered slowly so that the pile can be correctly inserted into the clamp. Once firmly inserted the jaws should be closed.

The EMV should then be started and the hydraulic rams adjusted so that the vibrator is level and always sits directly on top of the pile as it goes into the ground.

When the pile has reached the required depth the should be turned off, the hard jaws released from the pile and the lifting chain removed. These steps should be repeated for subsequent piles.

**12.0 Extracting Piles**

Before starting the excavator all safety procedures and maintenance should have been carried out and a check made to ensure that it is safe to move the dipper arm. The transport stand should be released from the jaws of the vibrator. The vibrator should be manoeuvred above the pile so that there is sufficient lifting chain to go through the eye of the pile.



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**12.0 Extracting Piles (continued)**

The lifting chain should be inserted correctly (no twists, knots etc.) and secured with the chain clamp. The vibrator should be clamped onto the pile head, ensuring that is level and a check made to ensure that all personnel are out of the working area.

The EMV should be started and the soil allowed to loosen. The pile should then be extracted whilst ensuring that the pile clutches are not rubbing together. Attention should be paid to the distortion of the rubber sandwich mounts – under no circumstance should the distortion exceed 30 degrees or 50 mm. Whilst there are mechanical stops present to protect the elastomeric elements, these are a back-up feature and the unit should not be allowed to run in this manner for more than a few impacts, as damage will result very quickly.

Once the pile becomes loose, the vibrator should be stopped and the clamp disengaged, ensuring there is no snatch loading on the lifting chain. The pile should then be lifted out of the ground by the lifting chain and moved to a suitable area, having first ensured that all personnel are out of the working area. The lifting chain should then be removed and the steps repeated for further piles.

**13.0 References**

Provision and use of work equipment regulations 1998 (PUWER)

Lifting operations and lifting equipment regulations 1998 (LOLER)

Control of Noise at Work Regulations 2005

BS 5228-2:2009+A1:2014, *Code of practice for noise and vibration control on construction and open sites. Vibration*

BS 6472-1:2008, *Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*

BS 7385-2:1993, *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration*

BS ISO 4866:2010, *Mechanical vibration and shock. Vibration of fixed structures. Guidelines for the measurement of vibrations and evaluation of their effects on structures*

HSE Publication GS6 - *Avoidance of Danger from Overhead Electric Power Lines 2013*, HSE Books

Piling Handbook 9<sup>th</sup> Edition, Arcelor Mittal (free download from <http://sheetpiling.arcelormittal.com/page/index/name/arcelor-piling-handbook>)

Shoring Technology Interest Technical Information Note TIN 202, *Schedule of Cold Formed Steel Sheets*, Construction Plant-hire Association (free download from [www.cpa.uk.net](http://www.cpa.uk.net))

Shoring Technology Interest Technical Information Note TIN 205, *Schedule of Plastic Piles*, Construction Plant-hire Association (free download from [www.cpa.uk.net](http://www.cpa.uk.net))

*Safe Use of Quick Hitches on Excavators - Best Practice Guide*. Strategic Forum for Construction - Plant Safety Group (free download from [www.cpa.uk.net](http://www.cpa.uk.net)).

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