Moving coal from the mine to the end-user equipment used to handle coal along the dry bulk supply chain

SCHADE has over 130 years experience in the mining industry altogether. Over the last 60 years, the company has specialized in the design and development of chain scraper type reclaimers for power plants, mining and minerals, coal preparation plants, bulk terminals as well as steel works and cement plants. With over 600 references worldwide including notable recent successes in China and Australia delivering ground-breaking state-of-the-art equipment to consumer and supplier, SCHADE remains a major player in the bulk handling market.

In 2001 SCHADE joined the AUMUND Group. Aumund is internationally renowned for its extensive range of bulk materials handling solutions for mining and core process industries, such as coal, steel and cement, including feeder equipment for track hopper discharge and an established range of wagon tipplers for the discharge of flat bottom open top rail wagons.

Figure 1 above is a composite illustration showing a typical European power plant with coal intake by hopper bottom rail wagon plus stacker and reclaimer equipment for stockpiling and blending of coals before conveying to the mill bunkers. Of course, in many locations around the world, hopper bottom wagons are not available and in these situations the wagon may be discharged manually or may be tipped on a frame to discharge the bulk cargo, typically coal or ores.

In the early years AUMUND developed a range of hydraulic wagon tipplers to discharge wagons either singularly or in pairs to a central hopper, as illustrated in Figure 2, left. Whilst this concept remains valid it has limited throughout capability and for high output applications AUMUND went on to develop the rotary wagon tippler, an early version of which is illustrated in Figure 3 on p47).

With the rotary tippler, the wagon is gripped by hydraulically operated clamps within a frame mounted to circular end rings supported on rollers with a rack and pinion style drive.

This allows the wagon to be rapidly inverted and the coal or raw material discharged to a hopper below.
Illustrated in Figure 4 (below, left) is a recent installation in Poland replacing a life-expired unit in the Szczecin coal export terminal. The tippler is 20 metres long and able to discharge up to 21 wagons per hour. Payload per wagon is around 60 tonnes giving a peak theoretical handling rate of 1,260tph (tonnes per hour).

This was a particularly challenging installation since the new tippler was to be used with the existing wagon charger and gravity wagon handling system.

As illustrated in Figure (below, right), the tippler was retrofitted within the existing concrete structure using the existing feeder and conveyor systems installed below.

In addition to the Polish order new installations are currently in progress for cement plants in Russia. There are other notable examples; such as in Vietnam at Nghe An Cement, working with a narrow rail gauge of only 1,000mm and, going back to 1991, at Sung Shin Cement Co., Korea, handling coal and gypsum.

With the integration of SCHADE into the AUMUND Group it became clear the wagon unloading system products were better placed in the SCHADE product programme. This maximizes the clear synergy between the SCHADE stacker/reclaimer systems and the railborne bulk intake wagon unloading systems as these functions are generally connected both at the terminal and at the process plant.

To maximize the market potential it was decided to extend the product portfolio to bring the existing equipment up to current expectation and introduce new products to extend the range of application including full automation. For this purpose, SCHADE has established a new sales and technical office in Bristol (UK) headed up by Matt Jones who, with his engineering team, has many years’ experience in this equipment working worldwide.

The original AUMUND design was in principle retained and designated the ‘O’ frame and two new tippler designs were added designated the ‘C’ frame and ‘pivot frame’ plus extended versions of the ‘C’ frame, in particular, to accommodate two rail wagons simultaneously for very high throughputs, the tandem tippler.

The general concept remains, see Figure 6, left, but updated
to current practice. For example the original design rotated the wagon through a full 360°, but the current design will be generally set to invert the wagon to a maximum of 180° returning to the upright by reversing the drive. This simplifies the rail alignment at each cycle and associated electrical connections and controls. As illustrated in Figure 6, the ‘O’ frame tippler features continuous top and side clamps for the rail wagon and is therefore more tolerant for use with a range of wagon specifications and dimensions.

The design is well balanced, with excellent structural integrity, allowing lighter construction and since the system is balanced the rotational drive torque demand is significantly reduced allowing more economical drive unit selection. The design may be extended to discharge two wagons simultaneously (tandem) to a central hopper and feeder system mounted directly below the tippler centre line. The ‘O’ frame tippler may be used with a wire rope capstan or chain system to charge the wagons into the tippler but is also available with a rail-mounted wagon charger as shown in Figure 7 above. This moves and positions the wagons in a controlled manner and eliminates any need for additional hauling gear or gravity run away systems, both of which require additional manpower and have potential safety implications.

Furthermore the wagon charger practically eliminates the need for any shunter or main line locomotive for the wagon handling until the whole rake is emptied and therefore available for collection by loco or movement by shunter.

Whilst the ‘O’ frame solution with the wagon charger represents a major step forward, clearly the charger arm cannot pass through the tippler frame and therefore its function is limited accordingly. The solution is the ‘C’ frame tippler from Aumund, as illustrated in principle in Figure 8 (bottom, left).

The general concept is similar to the ‘O’ frame but the end plates are cut and the frame opened to allow clear passage of the charger arm for rapid and accurate wagon positioning.

Clearly with this design there are significant structural implications and to retain the same level of structural integrity requires a much heavier construction but the benefits in terms of performance and automation are considerable.

As a single tippler, able to discharge one wagon at a time and with a single wagon charger, including full automation, the equipment can handle up to 30 cycles per hour. Since the charger may enter the tippler each wagon may be positioned accurately and reliably on every cycle with absolute repeatability.

However, as a tandem tippler, able to handle two wagons simultaneously and with the addition of a second charger acting as an indexer the equipment may handle up to 30 cycles per hour (60 wagons). That is equivalent to a peak rate of 3,600tph for standard four axle wagons holding 60-tonne payloads.

Clearly the key to achieving these high levels of performance is the integration of the charger and tippler controls such that the wagons are always perfectly positioned ready to be inserted...
to the tippler frame and discharged accordingly without delay.

The two charger units required for this level of performance are positioned one on each side of the main line rail track as illustrated in Figure 10 on p49 showing also a ‘C’ frame tandem style tippler.

Although both chargers are ostensibly similar, the second unit is known as an indexer in that it indexes the loaded wagons ready to be inserted into, or charged to, the tippler. In this manner, the wagon charging operation is split into two sections which may happen simultaneously therefore reducing the total time required to handle the wagons from the full to the empty side of the tippler. By reducing the total cycle time the number of wagons handled per hour is increased and therefore the overall system handling rate increases proportionally.

A typical wagon charger is illustrated above in Figure 11 and comprises a travelling four-wheel bogie onto which is mounted the hinged charger-arm which engages with the wagon coupling. The charger arm is raised and lowered with a hydraulic cylinder operated from an integral onboard hydraulic power unit. Long travel is generally derived from multiple rack and pinion drive units engaging a single rack fixed to the rail foundation.

The number of pinion drives is decided by the wagon mass and number of wagons in the train (rake) and therefore the total tractive effort required to move, accelerate, decelerate and hold the loaded wagons together considering the ripple effect along the length of the rake. Using multiple drives not only improves standardization but also reduces the shared pinion load and rack tooth shearing stress.

For smaller installations a simpler three wheel charger may be employed as illustrated in Figure 12, bottom left.

The concept is identical to the larger units but simply lighter with perhaps a single rack and pinion drive. Between these extremes almost any combination is possible with the further option of Chain haulage if considered appropriate.

In addition to the ‘O’ and ‘C’ frame designs, SCHADE also offers the pivot frame solution as illustrated in Figure 13 above, showing the empty tippler with a wagon charger beside.

In principle the pivot frame is, as the name suggests, a tippler mounted to a central pivot axle/bearing incorporating quadrant end plates for the rotational drive(s).

The design raises the wagon and inverts it over a box feeder or hopper mounted beside the main line rails as illustrated in Figure 14, below.

By discharging to the side of the main line this design is very flexible and may empty to a surface-mounted box feeder (Figure 15 on p53) or simple open bunker such that the bulk material may be recovered by wheeled loader for transfer to local stockpile.
Requiring only two pivot bearing supports the general alignment of the unit is less critical and there are no wheeled bogies to align and maintain. Since only a shallow excavation is required and the applied loadings are reduced the total cost of civil works is mitigated also. The shallow foundations are particularly interesting for port applications where typically the very high ground water level demands more sophisticated and therefore more expensive construction methods to avoid significant water ingress.

Since no deep excavation is required directly below the tippler the wagon platform may be supplied with a central support to further reduce the structural demands and may be equipped with a rail weigh system giving a throughout indication and totalizer.

When combined with a wagon charger and fully automated control the pivot frame design may achieve a performance rate of around 27 cycles per hour.

Various other options are also available for this design, working on the principle of inverting the rail wagon into a box feeder beside the rails such as illustrated above in Figure 15 handling peat for power plant.

The wide belt Samson™ feeder design by AUMUND is ideal for this purpose and, with the raised discharge, material may be easily transferred to the following conveyor.

In this particular installation the peat is unloaded from narrow gauge rail wagons at the mine site and loaded, using a mobile conveyor from B&W (AUMUND Group), for final delivery to the power plant or export facility by road tipping truck, as illustrated in Figure 16, left.

Of course the material could be transported by belt conveyor to a stacker/reclaimer from SCHADE or by truck to an intermediate stockpile area using a mobile stacker or any combination of operations is possible.
By combining mobile and static solutions, projects may be realized in phases for maximum flexibility and to minimize the total investment risk.

In addition to the major plant items as identified herein SCHADE also provide the ancillary equipment as part of the wagon unloading system package, such as wagon clamping and wheel gripper holding devices. Wheel grippers hold the side flange of the rail wheel and allow significant flexibility in wagon positioning, particularly suitable for the ‘O’ frame design where accurate wagon positioning is not so easy.

The wagon clamping system is generally matched to the type of wagon in use and may be top or bottom sill design where good standardization and repeatability of wagon specification and construction is necessary for reliable operation.

Longitudinal beams, as illustrated in the ‘O’ frame design, is far more tolerant and clamps the full length of the wagon top sill combined with side clamps securing and aligning the wagon laterally, see Figure 6).

In Figure 17 above, we see also the dual rotating drive units based on helical/bevel reduction motor gear units with a rack and pinion drive to each circular end frame along with positional sensors, interfaced to the PLC controller, signalling the relative rotational displacement through the revolution of the tippler body in both directions. A similar system is employed also for the ‘C’ frame and pivot frame designs.

Illustrated above in Figure 18 is the pivot frame tippler with beam clamps and showing a multi-drive wagon charger placing the wagon into the tippler. Beam clamps secure the wagon by the top sill using a bridge over the wagon with hydraulic actuators or ballast weights to secure the wagon into the tippler frame during the inversion phase.

For all of the functions described, both for the tippler and the wagon charger and indexer (where supplied), an effective integrated control system is necessary to ensure the proper sequenced operation for maximum performance.

SCHADE supplies a complete control package including all associated instrumentation, positional detectors and protection systems for the whole equipment package. This includes the associated festoon cable systems and power rails for the moving parts.

Programmable Logic Controllers (PLC) are included within each package to define the sequence and range of motions and interface to the variable speed Inverter drive controllers (VFD) and hydraulic valves for the wagon and wheel clamping systems. Using the VFD system, travel and rotational drives may be controlled for speed, acceleration and deceleration to allow fast movement with accurate positioning to minimize the lost time during the tippler and charger functions.

For the majority of applications, and particularly for high-performance installations, professional, permanent and dedicated under rail hoppers, feeders and material transport systems are mandatory.

In this area AUMUND offers a wide range of feeder equipment. For example, based on the armoured chain conveyor principle, as illustrated in Figure 19 (left, bottom), known as the PKF.

These feeders are robust and fully enclosed, dust- and spillage-tight, and as such ideal for operation beneath deep track
hoppers in confined areas where housekeeping is difficult.

The PKF feeder is available with a range of widths up to 2,600mm (depending upon the number of chains), allowing very steep hopper side walls to promote reliable flow when handling cohesive materials.

Of course these feeders, along with the associated hoppers as may be required, might be supplied within the wagon tippler package terminating to the ongoing belt conveyor system or including the associated stockyard equipment.

For really extreme applications handling heavy and lumpy materials the AUMUND type BPB-S plate feeder, as shown in Figure 21 (right), may be supplied beneath the under rail hopper.

These feeders may also be used beneath conventional track hoppers for hopper bottom rail wagon discharge of the type as shown in Figure 1.

In addition to the major plant items as identified here, SCHADE also provides the ancillary equipment as part of the equipment only supply package, such as enclosures and dust control systems plus connecting conveyors and bunker/feeder systems at every stage of the logistics chain from mine-site to processor.

This extensive new range of wagon tipplers, combined with existing AUMUND Group products, places SCHADE at the leading edge of wagon unloading systems technology and is an important new capability within the AUMUND Group.

And, when combined with SCHADE stacker and reclaimer products and AUMUND Group conveying and feeder products offers the client a single source of supply for a large element of the key components required for the intake and subsequent storage systems necessary for bulk terminals, power and process plant receiving railborne dry bulk cargoes.

Sumitomo bucket elevator unloader popular for continuous unloading of coal

Sumitomo Heavy Industries Engineering & Services Co., (SES) specializes in cranes and material handling machinery within the Sumitomo Heavy Industries Group, a major Japanese heavy industry concern. Its business covers the entire life-cycle of cranes and material handling machinery, starting from R&D, engineering, manufacturing, commissioning and maintenance, through to after-sales services.

**Main products**

One of Sumitomo’s main products is the bucket elevator type continuous ship unloader (CSU). Since delivering its first CSU in 1976, Sumitomo has pursued high efficiency of unloading with deliveries mainly to power plants and steel mills.

**Orders in hand**

<table>
<thead>
<tr>
<th>Year</th>
<th>Industry</th>
<th>Capacity Unit</th>
<th>Material handled</th>
</tr>
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<tbody>
<tr>
<td>2008</td>
<td>Chemical</td>
<td>1,500tph 1</td>
<td>Coal</td>
</tr>
<tr>
<td>2008</td>
<td>Steel Mill</td>
<td>3,500tph/ 1 2,100tph coal</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Power Plant</td>
<td>2,200tph 2</td>
<td>Coal</td>
</tr>
<tr>
<td>2010</td>
<td>Power Plant</td>
<td>1,400tph 1</td>
<td>Coal</td>
</tr>
</tbody>
</table>

**Bucket elevator type CSU: special features**

- heavy emphasis on environmental protection (low vibration, noise and dust emission and energy consumption):
  - totally enclosed material pathway minimizes dust emission;
  - installation of water spray dust suppression at digging head and chutes; and
  - extensive use of inverter motors instead of hydraulic drives to minimize maintenance and risk of oil spillage.
- high unloading efficiency:
  - swing-out feature of bucket-elevator enables it to reach deep into the ship’s hold to reach most of the materials without bulldozer work;
  - catenary mode enables efficient hold bottom clean-up,
- minimizing bulldozer work;
- automatic traverse mode, combining machine slewing and travelling motions, enables the CSU to continuously move the digging head in an optimum pattern in the hold to achieve high efficiency of unloading; and
- automatic ‘peak cut control’ enables the CSU to discharge material onto the dock conveyor at a constant rate, minimizing peak loads, enabling downsizing of all downstream equipment.
- high reliability and safety considerations:
  - all structural fatigue calculations follow stringent standards;
  - overload protection system to prevent structural stresses; and
  - fatigue life monitoring system (optional) enables preventive measures to reduce maintenance burden.
- outstanding maintainability (fulfillment of minimized maintenance time and cost):
  - all main motions, except for boom luffing and some secondary motions are electrically powered (instead of hydraulics), which improves performance, maintainability and reduces maintenance costs; and
  - guide rails for bucket chain have been eliminated to minimize wear.