
Development of a Roll-Off Container Handling and Dumping System (Ground Level or into a Railroad Car) for Off-Highway Articulated Trucks

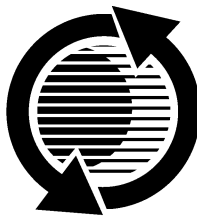
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Development of a Roll-Off Container Handling and Dumping System (Ground Level or into a Railroad Car) for Off-Highway Articulated Trucks

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ABSTRACT

This paper describes the development and manufacture of roll-off container handling systems for off-highway articulated trucks. This presentation reviews systems incorporating four unique products covering various roll-off container handling alternatives. The various components described and, depending on the style of the system, incorporated into a system are:

1. An off-highway truck "J"-Hook arrangement for picking roll-off containers up off of the ground and pulling them onto a haulage vehicle.
2. An automatic tailgate locking and opening system for roll-off containers vs. a manual vehicle driver dependent door/tailgate system.
3. A scissors lift for lifting roll-off containers to be dumped into various other vessels (railroad gondola cars, etc.).
4. A unique "J"-Hook interface for standard 20-ft. intermodal roll-off shipping containers so they can be hooked onto and handled with a "J"-Hook.

Both the automatic locking/unlocking tailgate and the scissors lift are features which may or may not be incorporated in every unit. The equipment discussed in this paper opens new avenues for off-highway trucks in steel mills, landfills, quarries, etc.

INTRODUCTION

The title of this paper in addition to that indicated could easily be:

- a. Finding the "missing (roll-off container) link." (Figure 1)
- b. The commercialization of off-highway articulated trucks for roll-off container material haulage.
- c. The turning of roll-off containers into a commercially viable product for high-volume material haulage.
- d. Safer roll-off container material haulage.



Figure 1. Missing Link

These titles are appropriate to the products discussed and putting this paper together has crystallized the significant contributions these products make to the viability of short-haul, high-volume roll-off containerized material haulage.

BACKGROUND—ROLL-OFF CONTAINERS—It is not known when roll-off containers first came into their own. It was probably on building-construction projects when the standard "dumpster" simply was not big enough to hold the waste materials generated. And, the rate of material generation was such that it was not practical to simply park a (dump) truck on site and wait for it to be filled—sometimes a half-day process, sometimes a 2-3 day to one-week process. Instead, it made sense to drop a truck body at the point where material was being generated and later come back to pick up that truck body and haul material off for disposal. Thus, the roll-off container concept; i.e. roll a truck body off onto the ground, and when it gets filled up, roll it back on to a truck chassis for hauling and dumping. In this context, speed with which containers could be handled—picked up, dropped off, dumped—was of little importance compared to the total haul cycle time, which in some cases was over a week. The concept of roll-off container construction project waste material haulage did not have to fit a high production haulage operating mode.

Yes, the Kiruna Company of Sweden developed an offshoot of the roll-off container concept for higher produc-

tion material haulage used in the mining industry, though the Kiruna concept is based around a total Kiruna material haulage system, i.e. trucks, containers, and ancillary interfacing equipment.



Figure 2. "Winch" Based Roll-Off Container Transport Truck

The origin of the roll-off container name? When loaded, it rolls onto the transport vehicle and, when empty, it rolls off the transport vehicle. Originally, roll-off containers used a transport truck with winch and a structure for either rolling the "roll off" container up-onto or off-of the transport truck. This system is transport truck driver dependent. The transport truck driver hooks a cable to the roll-off container for pulling it onto the transport truck and unhooks the cable from the roll-off container when it is (dropped) rolled off of the transport truck.

FURTHER BACKGROUND – "J"-HOOKS AND ROLL-OFF CONTAINERS – More efficient "J"-Hook roll-off container loading/ unloading systems which are less transport vehicle driver dependent have recently come on the market. The "J"-Hook system utilizes a transport vehicle driver controlled hydraulically actuated hook-to-hook onto a roll-off container and lift/roll the roll-off container up onto the transport vehicle, and likewise lower/roll the roll-off container off the transport vehicle when parking the container for material loading. The operator stays in the transport vehicle cab while picking up or dropping off the roll-off container—a major improvement over "winch" based systems in both operator safety and operating efficiencies. (Figure 3)

ENHANCING BOTH TRANSPORT VEHICLE OPERATOR SAFETY AND ROLL-OFF CONTAINER HAULAGE EFFICIENTLY

Both the conventional roll-off container winch operating system and the more efficient "J"-Hook container handling system still, however, have the same drawback – the roll-off container door/tailgate. When dumping the conventional roll-off container for either system, the transport vehicle driver has to:

1. Exit the vehicle
2. Unlock the container door/tailgate

3. Re-enter the vehicle cab
4. Dump the container
5. Drive the transport vehicle slightly forward
6. Lower the container
7. Vacate the transport vehicle cab
8. Re-lock the container door/tailgate, and then
9. Enter the transport vehicle and drive to the next roll-off container drop-off/pick-up point.

THE ROLL-OFF CONTAINER DOOR/TAILGATE OPERATION – This roll-off container door/tailgate challenge is not much of a problem with relatively small containers and where dumping time compared to total haul cycle time is miniscule. On the other hand, with larger roll-off containers and off-highway (higher gross vehicle weight) transport vehicles, the roll-off container door/tailgate is harder to operate (bigger doors, higher of the ground). In addition, in an off-highway haulage environment, haul cycle times would be (in theory) much shorter so with conventional roll-off container doors/tailgates dumping time relative to total haul cycle time could be considerable. So to transition roll-off containers from the on-highway to the off-highway haulage market, a roll-off container door/tailgate system was needed to make high-volume, off-highway containerized material haulage practical.

REQUIREMENTS FOR PRACTICAL OFF-HIGHWAY ROLL-OFF CONTAINERIZED MATERIAL HAULAGE –

- a. Transport hauler operator safety
- b. Larger containers
- c. Larger payloads
- d. Move a higher volume of containers, with travel limited to a rather discreet area, travel distances and travel times would be shorter and more roll-off containers could be moved. An example would be scrap material haulage in a steel mill.
- e. Minimize transport vehicle driver ingress/egress from the vehicle cab.
- f. A roll-off container door/tailgate that is transport vehicle driver independent and fast acting, as:
 1. The roll-off container is higher off the ground—off-highway truck frames are typically higher than on-highway trucks.
 2. A transport vehicle driver dependent roll-off container door/tailgate adds a minimum of 5-7 minutes to total haul cycle time, so a 10-minute haul cycle can easily go to 15-20 minutes.
 3. Without a transport vehicle driver independent roll-off container door/tailgate overall practicality of off-highway, roll-off containerized material haulage drops by a factor of two (2) since to dump a load the following would have to occur:
 - a. Stop the roll-off container transport hauler wherever the roll-off container will be dumped

- b. Set the brakes on the roll-off container transport hauler
- c. Exit the hauler cab
- d. Unlock the container door/tailgate
- e. Get back in the hauler cab
- f. Dump the container
- g. Unlock the hauler brakes
- h. Drive forward
- i. Lower the dumped container
- j. Set the hauler brakes
- k. Exit the hauler cab and re-lock the container door/tailgate
- l. Get back in the hauler cab and unlock the hauler brakes to continue with the haul cycle.

MOVING TO SUCCESSFUL OFF-HIGHWAY ROLL-OFF CONTAINER MATERIAL HAULAGE – In steel mills and like operations, efficient material haulage requires drop boxes or roll-off containers so pick-ups and drop-offs can be made from multiple loading points as containers fill every hour to every few hours. How, then, to transition the roll-off container concept from a sometimes material haulage system to a production haulage mode? How to go from intermittent on-highway roll-off container material transport to off-highway high-production roll-off container material transport? The singular benefit of the roll-off container concept is slow loading rates where loads can be allowed to accumulate every hour or so with roll-off container systems supporting multiple material loading points without stationing a dedicated haulage vehicle at each loading point.

To successfully transition roll-off containers for off-highway material haulage, the conventional roll-off container operating mode for refuse, waste, scrap material, etc. requires a significant shift in standard “modus operandi.” Reasons for this shift from the standard on-highway method of doing things:

- a. Transport hauler driver safety.
- b. If a hauler driver dependent roll-off container door/tailgate increases haul cycle time by 66%-100%, quite possibly another transport hauler and operator would be required to move the same number of roll-off containers.

An automatic roll-off container door/tailgate system – An automatic roll-off container door/tailgate system in both the on/off-highway environments would have the following benefits:

1. Safety: Driver stays in the safety of the hauler cab during the entire container hauling dumping process.
2. Shorter haul cycle times: Minutes taken off the dumping cycle shortens total haul cycle time from what might be double of that with a driver dependent roll-off container door/tailgate.

3. With shorter haul cycles, maximum container transport vehicle utilization is obtained.

Thus, off-highway high-production roll-off container material handling will:

1. Keep the operator in the hauler cab.
2. Automate the container pick-up and drop-off process.
3. Automate the container door/tailgate opening and closing.

To accomplish this, start with a “J”-Hook for picking up and dropping off the roll-off container and then add the “Missing Link” to the roll-off container door/tailgate, automating tailgate actuation—with an “Autogate[®]” concept. Combine the “J”-Hook and Autogate[®] with an off-highway articulated hauler and short haul roll-off container material hauling and dumping is transitioned from the impractical to a practical, profitable, cost-effective material haulage system.



Figure 3. An Off-Highway “J”-Hook

AUTOMATING THE ROLL-OFF CONTAINER TAILGATE – Automating the roll-off container tailgate starts with a tailgate design originally developed for the off-highway hauler industry, adapt this tailgate to a roll-off container and then develop a means for actuating the tailgate—“The Missing Link.” This roll-off container tailgate concept has previously found widespread use on haulers through 320-ton capacity.

The automatic transport hauler driver independent roll-off container door/tailgate consists of:

1. An outrigger attached to the haulage vehicle’s frame;
2. A counter-weighted roll-off container Autogate[®] actuation hookup point pivoting off of the outrigger attached to the haulage vehicle’s truck frame;
3. The “Missing Link” from the roll-off container Autogate[®] to the Autogate[®] actuation hook up point mounted off the haulage vehicle’s truck frame.



Figure 4.1. Hooking Up To A Roll-Off Container



Figure 4.2. Picking Up/Dropping Off A Roll-Off Container



Figure 4.3. Engagement of the Autogate[®] Actuation Hook-Up Point and the "Missing Link"



Figure 4.4. Opening of the Roll-Off Container Autogate[®]

A simple "Why didn't I think of that?" invention which opens the door to a whole new set of haulage applications for articulated off-highway trucks.

One might ask why articulated versus rigid-frame off-highway haulers:

1. To successfully pick-up roll-off containers, the containers need to be at least 20 ft. in length and a rigid truck's frame/wheel base is too short to put a 20 ft. long container on the back of the hauler. On the other hand, articulated trucks by their very nature are long-framed, long wheel base vehicles.
2. Off-highway articulated haulers by their very nature have a lower frame height than off-highway rigid frame trucks and thus roll-off containers do not have to be lifted as high in the pick-up process.
3. Off-highway articulated haulers can maneuver into tighter spots than off-highway rigid frame trucks.
4. Because of maneuverability it is easier to hook-up/drop-off from a roll-off container "J"-Hook mounted on an off-highway articulated hauler, the truck's articulation allows steering the "J"-Hook into the container hook up point.

So, an off-highway articulated hauler having a "J"-Hook , a roll-off container, an Autogate[®], and the "Missing Link," creates a totally operator independent roll-off container

material handling system. Articulated off-highway haulers and roll-off containers then come into their own for high-volume, containerized material haulage from multiple loading points opening up new markets for off-highway articulated haulers and roll-off containers.

A further enhancement of this off-highway articulated hauler roll-off container handling system occurred with the ability to load roll-off containerized material into long-haul haulage vehicles—over the road semi-s, railcars, etc.—with an elevated roll-off container dumping system. This off-highway articulated hauler elevating containerized haulage/dumping system combined

- a. "J"-Hook roll-off container pick-up/drop-off system, with
- b. An automatic container door/tailgate opening/closing system with
- c. A scissors lift for elevating roll-off containers to dump over the sides of other long-haul units, railcars, etc. (Figure 5)



Figure 5. Off-Highway Hauler Scissors Lift

Integrating these three independent systems further increased the versatility of articulated off-highway hauler roll-off container transport units. The system illustrated handles 55-60 containers in an 8-hour shift. (Figure 6.1 and 6.2) What is the alternative to this system? Dump material, load it into the railcars with a loader or dump material into a conveyer, and move railcars along underneath the conveyer for load placement. Neither alternative is desirable. Why re-handle material if one does not have to?



Figure 6.1. A Roll-Off Container Backed Up To A Rail Car Ready to Dump



Figure 6.2. Dumping a Roll-Off Container Into a Railcar

A “J”-HOOK TO STANDARD 20-FT. INTERMODAL ROLL-OFF SHIPPING CONTAINER INTERFACE – In the course of developing the elevated roll-off container dumping application, a standard intermodal roll-off container interface/hook was developed that adapts 20-ft. industry standard intermodal roll-off containers to a “J”-Hook system to pick up and drop off containers.

FURTHER PRODUCT ENHANCEMENTS

Are there other enhancements to the product? In the current “J”-Hook design we are moving from a hybrid on-highway/off-highway “J”-Hook design to a strictly off-highway “J”-Hook designed for larger loads and more strenuous usage.

As an aside, the design methodology between on-highway and off-highway units is radically different. In on-highway product design every pound of material matters. The design approach walks a tight rope between being just strong enough to do the job, but yet as light as possible to maximize net payload while not exceeding legal gross vehicle weights. On the other hand, off-highway product design is typically limited first by vehicle tire capabilities and next by mechanical structure, so tare weight, though always an issue, is not the killer it is with on-highway equipment design. Asking an engineer who has worked on one side of the fence, on-highway design,

to switch to the other, off-highway design, can be a traumatic experience. One has to change their entire focus. On-highway product design methodology is thus radically different from off-highway product design methodology.

The current off-highway “J”-Hook design utilizes the off-highway truck frame as the “J”-Hook base member thus eliminating a separate base structure, which is rarely possible with much lighter in comparative strength on-highway truck frames. The dump member is fabricated out of ultra high-strength steel plate versus standard structural tube. The intermediate section also uses ultra high-strength steel plate fabricated into box type members, while the dump and tilt cylinders are larger bore, larger rod cylinders operating at lower hydraulic pressures. (Off-highway haulers as a standard have a hydraulic dump circuit and thus an off-highway hauler “J”-Hook operates from existing hydraulic system/ pressures to create a true heavy-duty off-highway “J”-Hook arrangement.) (Figure 7)

The discussion throughout this paper points to the parallels between on-highway design and off-highway design. This paper also points out that what is good enough for one is not so readily adaptable to the other though on the surface both methods of moving materials seem quite similar. The point for designers and users of equipment would be that the obvious – simply taking on-highway equipment and putting it into an off-highway environment – sometimes is just not an option. The subtleties of this project have implications for every equipment designer. Just because a product works in one place, there is absolutely no guarantee it will work in an entirely different though similar application. So as equipment designers, let us not be fooled.

As was found in this product development, the “Missing link,” a link to hook the container door/tailgate to the transport vehicle actually dealt with many issues all leading to the practical commercialization of off-highway articulated trucks in roll-off container material transport. This “missing (tailgate) link” is likened to the last few pieces needed to complete a jigsaw puzzle. Something I, the author, came to appreciate as this paper was put together.

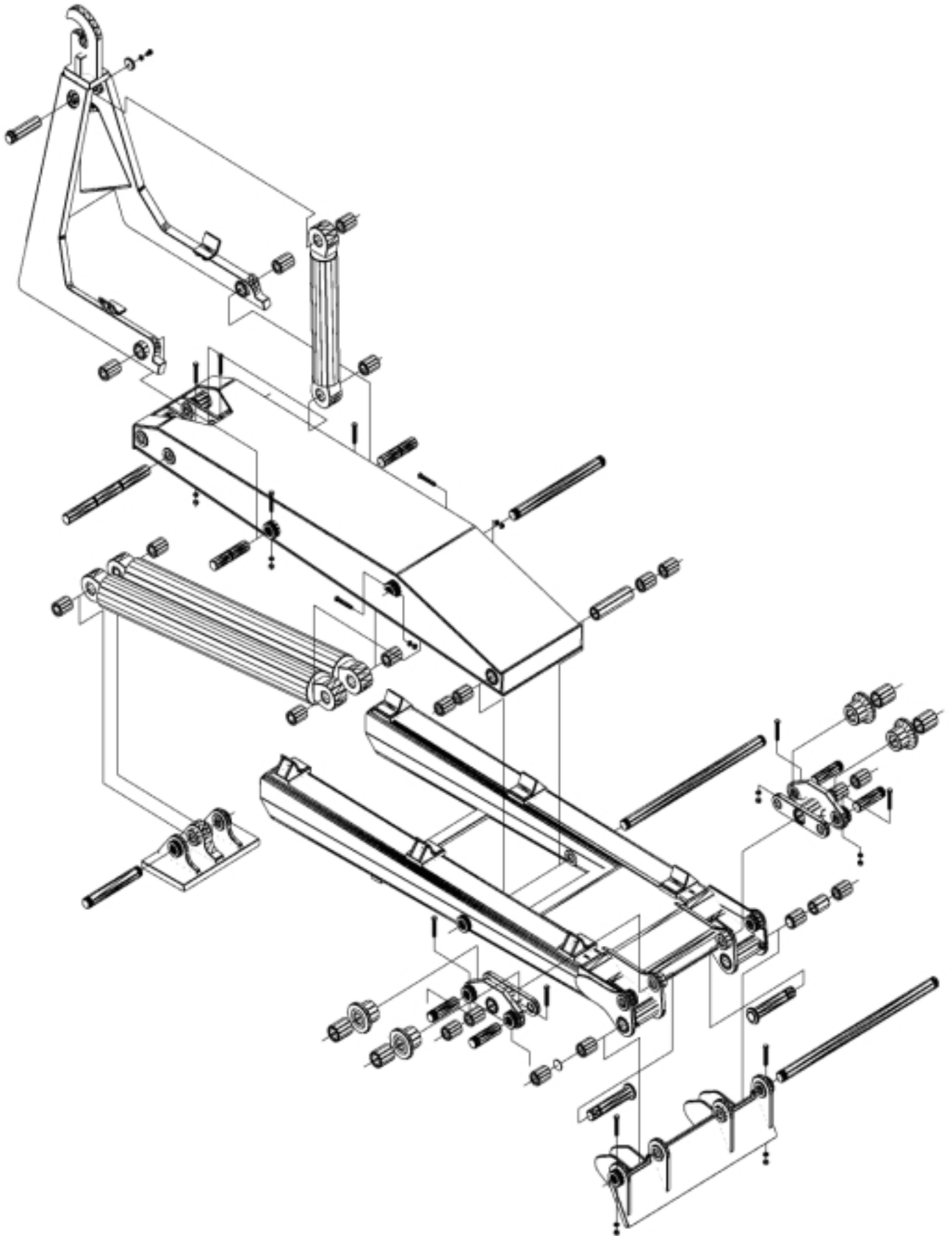


Figure 7. Off-Highway Hauler "J"-Hook Components