Bulk Europe 2006
International Conference on Storing, Handling and Transporting Bulk
Barcelona, Spain; October 16-17, 2006

Motorized Pulleys Solve Harsh Environmental Problems at North American Ship Loading Terminals

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Keywords: Motorized Pulleys, Ship Loaders, Bucket Wheel Stacker Reclaimers, Conveyor Belts

1 Abstract

This paper presents design and operational challenges faced by three different ship loading facility operators, one handling export coal on the Gulf of Alaska and two handling taconite iron ore pellets on the North American Great Lakes. Extreme temperatures and abrasive materials, coupled with a need for compactness, made internally-powered and hermetically-sealed Motorized Pulleys the optimal design choice for driving ship loader and bucket wheel reclaimer conveyor belts.

Originally a European idea, the Motorized Pulley was slow in gaining acceptance in North America in the twentieth century. However, the internally-powered conveyor belt drive has recently become more popular, especially where ambient conditions, material handled, or compact equipment design make exposed drives difficult to integrate and operate.

Fig. 1: Alaska Railroad right of way passes through rugged mountain passes from Usibelli Coal Mine in Healy, AK to ARRC Coal Export Terminal in Seward, AK.

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2 Introduction

What do Seward, Alaska; Superior, Wisconsin; and Escanaba, Michigan have in common? Each is the location of a major rail-to-ship bulk storage and transfer facility, owned and operated by a railroad company. Each is located on water north of 45ºN latitude, where winter temperatures can drop to –40º F (-40ºC) and humidity reach nearly 100%. And each handles abrasive and/or corrosive material. One other important feature is common to these facilities...the Rulmeca Motorized Pulley. Rulmeca's internally-powered and hermetically-sealed Motorized Pulley was selected to upgrade key drives on shiploader and bucket wheel reclaimer conveyor belts.

Fig. 2: Self-unloading lake vessel, 1,000 feet (300 m) long, crushes through icy Great Lake to pick up taconite ore pellets from the Minnesota Iron Range for Great Lake steel mills.

This paper will review each facility's layout, throughput, and particular challenges and it will explain why designers selected Motorized Pulley technology. These successful applications will help explain the growth in acceptance of Motorized Pulley technology in North America, especially in harsh environments.

3 Motorized Pulley Technology

The Motorized Pulley concept was developed in the 1950's to provide a reliable means of driving belt conveyors. Equipment designers quickly discovered that enclosing the drive's motor and gearbox within a hermetically-sealed and oil-filled pulley shell not only made the drive compact, it also greatly improved the drive's reliability and service life.

Fig. 3: Rulmeca Motorized Pulley encloses motor and gearbox within hermetically-sealed oil-filled shell to protect moving components from harsh environment while saving space.

Compactness, reliability, long service life, and limited maintenance requirements made the Motorized Pulley a popular conveyor drive for bulk handling equipment designers in Europe. Large machinery such as bucket wheel reclaimers, ship loaders, and tunnel boring equipment soon had Motorized Pulleys installed as original equipment. And plant operators began replacing worn exposed conveyor drives with Motorized Pulleys at facilities handling materials such as fertilizer, sand & gravel, steel, ore, and wood products.

Each Motorized Pulley consists of an AC squirrel-cage induction motor, directly coupled to a helical/ spur gearbox, mounted on a fixed (non-rotating) shaft, and hermetically-sealed within the cylindrical pulley shell. Today's Motorized Pulley incorporates a wide array of powers and speeds as well as optional features such as built-in mechanical backstops, anti-condensation heaters, and electro-mechanical brakes.

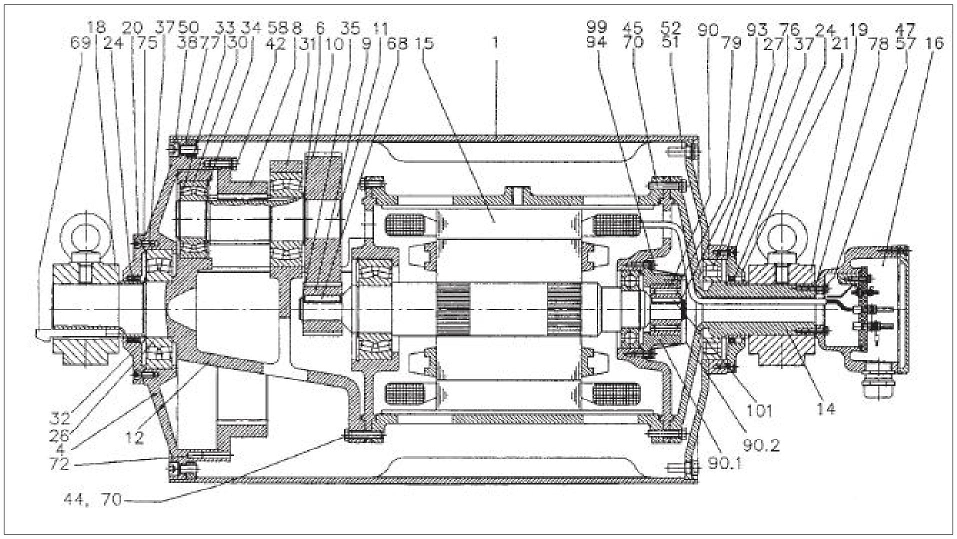

Fig. 4: Rulmeca Model 800H Motorized Pulley with two-stage helical/spur gearbox directly coupled to AC squirrel-cage induction motor. Pulley is 33% filled with oil to lubricate moving parts and cool motor. "Drip lips" welded to pulley shell continuously pour oil on (and cool) motor stator. Gearbox is above oil to eliminate oil frothing.

4 Seward Shiploading Facility

4.1 Synopsis of Upgrade

Alaska Railroad Corporation (ARRC) increased the shiploading rate from 800 to 2,000 TPH at the company's 22 year old rail-to-ship Seward Loading Facility (SLF) on Resurrection Bay, Alaska in 2005 as part of a facility acquisition and upgrade to decrease operating costs and revive export of Alaskan steam coal to Korea and other export markets.

Fig. 5: Seward Coal Terminal's newly upgraded shiploader transfers coal to 92,000 DWT ships at 2,000 TPH

4.2 Objective of Upgrade

The Shiploader upgrade was part of an overall upgrade, which also included increasing the stockpiling rate from 3000 to 5000 TPH as well as expansion of the coal storage yard. Funded by a $9.5 million Federal Railroad Administration grant, ARRC revived Alaskan coal exports by acquiring the SLF from Hyundai Merchant Marine and Alaska Industrial Development and Export Authority thereby eliminating the loan principal and interest payments and decreasing the cost of Alaskan coal. $1.24 million of the grant was earmarked for inspections, repairs, and improvements. ARRC hired Krech, Ojard, & Associates of Duluth, Minnesota in December 2003 to do preliminary engineering and development of an improvement plan.

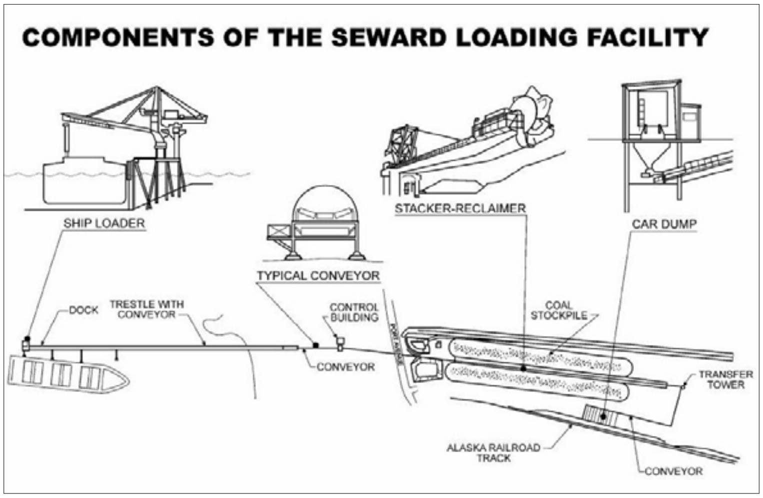

Fig. 6: Seward Loading Facility upgrade increased shiploading rate from 800 to 2,000 TPH increased stockpiling rate from 3,000 to 5,000 TPH and expanded coal storage yard.

Fig. 7: Seward non-traveling , luffing, slewing shiploader uses Model 630H 75 HP (55 kW) Rulmeca Motorized Pulley to drive 42 inch (1,1 m) wide shuttle boom conveyor at 800 FPM (4 m/s).

Fig. 8: Rail-mounted bucket wheel reclaimer is primary component in 120,000 metric ton stockpile area.

Fig. 9: Bottom-dump pit unloads Usibelli coal from Alaska Railroad cars at 5,000 TPH providing a 3 million metric ton per year throughput capacity.

4.3 Historical Background

Construction of the Seward Loading facility in 1984 opened Alaskan steam coal to the export market when Usibelli Coal Mine (UCM) began shipping coal from its Healy, Alaska mine to the Honam Electric Power Generating Plant in South Korea as part of a long term contract. UCM delivered 12 million tons of steam coal during the 18 year relationship. Coal shipping ceased in 2002 when the supply contract was not extended. Shipments resumed in 2003, after the ARRC acquisition, at two trains per week. Coal handling rates increased in late 2005 when phase one of the conveyor upgrades were completed. UCM is now delivering 400,000 tons/year for the Honam plant.

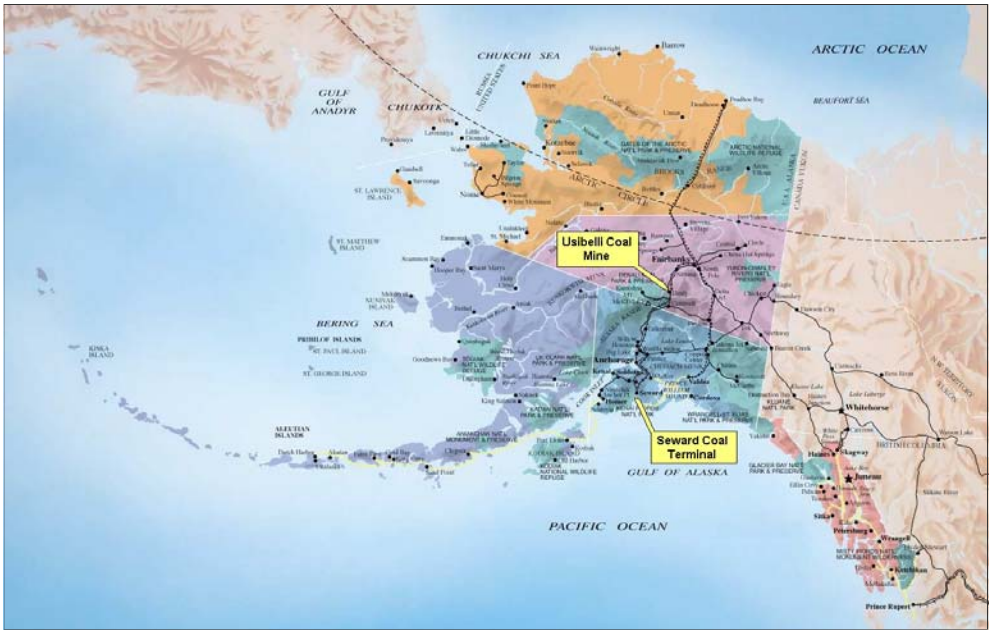

Fig. 10: Alaska Railroad resumed the export of Usibelli Coal from Healy to Honam, South Korea via the Seward Coal Terminal in 2003 after ARRC acquired and upgraded the Seward Terminal.

4.4 Operating Data

Table 1: Seward Coal Terminal	
Annual throughput	3 Million TPY
Storage Capacity	120,000 Tons
Train Unloading Rate	5,000 TPH
Reclaim Rate	2,000 TPH
Shiploading Rate	2,000 TPH
Max Vessel Size	92,000 DWT
Train Size	80 cars
Max Draft at Dock	53 FT (16,2 m)

As shown in Table 1, the 34 acre Seward Loading Facility is configured with a rail loop encircling a 120,000 metric ton stockpile, a bottom-dump rail car unloader, a bucket wheel stacker reclaimer, and a non-traveling luffing and slewing shiploader with a shuttle boom. With a maximum draft of 53 feet (16,2 m), the dock is designed to load 92,000 metric ton cape-size vessels and is one of the deepest ports in the United States. Panamax vessels (up to 80,000 metric tons) are optimal. Annual throughput capacity is 3 million metric tons per year. Since the facility is located at 60° N latitude, just 800 miles (1300 km) south of the Arctic Circle, winter temperatures are severe.

Fig. 11: Extendable shiploader spout directs coal from shuttle belt into ship at 2,000 TPH while minimizing fugitive dust emissions.

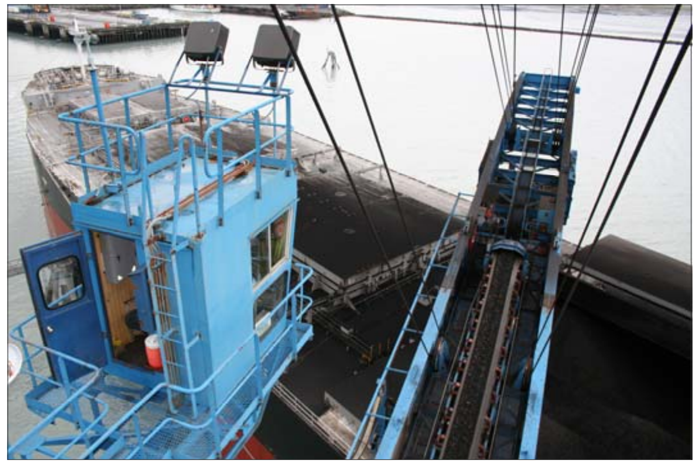

Fig. 12: Photo shows discharge point from fixed boom conveyor to shuttle boom conveyor.

Fig. 13: Model 630H 24 inch (630 mm) diameter Rulmeca Motorized Pulley minimized congestion and weight at the cantilevered shuttle-to-chute transfer point.

4.5 Motorized Pulley Experience

When increasing the ship loading rate from 800 to 2000 TPH, Krech, Ojard, & Associates specified more powerful drive systems for all of the conveyors in that circuit. However, they were faced with a dilemma on the shuttle boom conveyor drive… how to install a 75 HP (55 kW) motor, gearbox, and pulley in the restricted space of the shuttle support structure without expensive major modifications. The solution came when Roger Meittunen of Engineering Design Services suggested a Rulmeca Motorized Pulley to Krech, Ojard, & Associates designers. The Model 630H provided a 75 HP (55 kW) motor powered by the facility's 460V/3PH/60Hz power supply in a

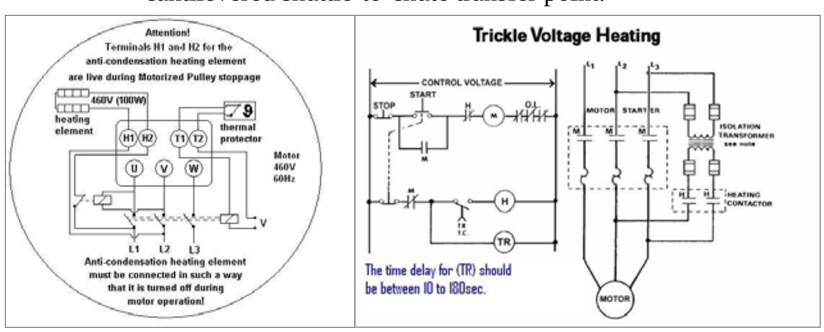

Fig. 14: (Left) Krech, Ojard, & Associates specified a built-in 100 Watt anti-condensation heater due to Alaskan winters. (Right) "Trickle Voltage" heating is anti-condensation alternative for winter outages.

" narrow footprint" of 24 inch (630 mm) diameter, 47.24 inch (1200 mm) face width, with a mounting bracket spacing of only 59 inches (1500 mm). Only minor changes were required to remove the old pulley, pillow blocks, and drive system to accommodate the Motorized Pulley. Another interesting feature of this project is the use of a 460V/100watt anti-condensation heater built into the Motorized Pulley, as shown in figure 14.

Fig. 15: First of three 40 year old crawler-mounted bucket wheel reclaimers upgraded by BNSF with three Rulmeca Motorized Pulleys (one on boom and two on tail.)

5 Alllouez Dock #5

5.1 Synopsis of Upgrade

Burlington Northern Santa Fe Railroad (BNSF) recently completed the overhaul of two of three 40 year old crawler-mounted bucket wheel reclaimers at the company's rail-to-ship transfer terminal for taconite pellets located near Superior, Wisconsin.

Fig. 16: Allouez Dock#5 stockpiles 5.5 million tons of taconite pellets in 87 acre (0,3 km^2) storage area 3.5 miles (5,6 km) from shiploader. A 5.7 mile (9,2 km) network of conveyors link the two bottom-dump rail car unloaders, 3 stacker/reclaimers, and 36 silo fixed shiploader.

5.2 Objective of Upgrade

The objective of the upgrade was to reduce high maintenance expense while improving system reliability in the stockpile area. The upgrade included structural changes, replacement of on-board diesel engines, and the installation of Rulmeca Motorized Pulleys. The challenge for BNSF operations was to keep the 40 year old machines working efficiently in spite of the fact that the machines' manufacturer had gone out of business more than 20 years ago. The original conveyor drives were a unique combina-

Fig. 17: Since reclaimer manufacturer went out of business more than 20 years ago, BNSF was forced to custom-build replacement parts such as the unique 200 HP (150 kW) planetary gear driven tail conveyor.

Fig. 18: Tandem 120 HP (90 kW) Model 800 H Rulmeca Motorized Pulleys replaced the original drive, each powered at 460V/3PH/60Hz by a new on-board diesel generator.

tion of components including AC motors, planetary gearboxes and pulleys mounted between the carrying and return strands of belt. Since original equipment manufacturer's parts were no longer available and since the conveyor drives were non-standard, BNSF was forced to custom-build parts, an expensive and time-consuming process. Engineering Design Services recommended Rulmeca Motorized Pulleys because: (1.) they are compact and would fit within the reclaimers' structure, (2.) Rulmeca Motorized Pulleys and replacement parts are readily available, and (3.) Rulmeca has a long successful track record of supplying conveyor drives for bucket wheel reclaimers.

Fig. 19: Original boom conveyor used 100 HP (75 kW) electric motor located between carrying & return strands of belt direct-coupled to external planetary gearbox.

Fig. 20: Only minor boom structure modifications were required to replace obsolete drive with standard 120 HP (90 kW) 800H Rulmeca Motorized Pulley in 2004.

5.3 Historical Background

The growth of the Duluth/Superior area is tied with the introduction of the railroad in 1870; dredging of the harbor, which began in 1873; and shipment of iron ore, which began at Allouez Dock #1 in 1892. The 1855 opening of the Soo Locks gave unobstructed passage to vessels going to and from Lake Superior. 50,000 tons of iron ore were shipped from Duluth/Superior in 1929. BNSF set an operating record in 1953 when the company transferred 32.3 million tons of ore. The 1959 opening of the St. Lawrence Seaway not only gave Minnesota iron mines access to export markets it also allowed competitive foreign ores to be delivered to the

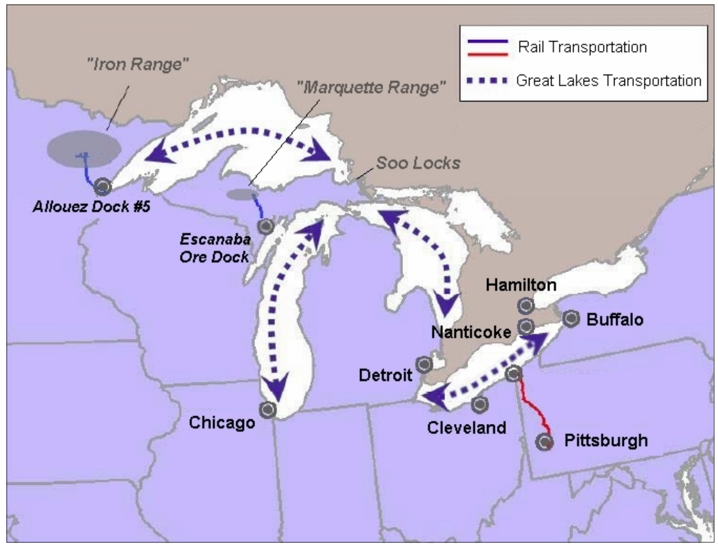

Fig. 21: Enlargements of Soo Locks in 1919, 1943, and 1969 made it possible for large lake vessels to carry iron ore from Allouez Dock to steel mills near Chicago, Detroit, Cleveland, Buffalo, Pittsburgh, Nanticoke, and Hamilton. Iron ore shipments from Allouez Dock peaked at 32.3 million tons in 1953.

Fig. 22: Allouez-bound 150 car ore train passes through Scanlon, MN.

Fig. 23: Oglebay Norton, a huge 64,000 DWT lake vessel arrives at Duluth Harbor in winter weather.

Fig. 24: Long lake vessels are loaded at 1,400 foot (430 m) Allouez Dock #5 . 36 concrete silos store 72,000 tons of pellets at dock. Note that self-unloading ship's boom extends starboard to clear loading conveyors.

lower ports on the Great Lakes. Currently BNSF Allouez Dock #5 transloads 14.5 million short tons of taconite pellets per year, originating at Hibbing Taconite's Hibbing, MN mine and Keewatin Taconite's Keewatin, MN mine. Lake vessels haul the ore to steel mills at Burns Harbor and Indiana Harbor, Indiana; Detroit, Michigan; and Hamilton and Nanticoke, Ontario.

Fig. 25: Cable-hoist luffing system enables rail-mounted stacker reclaimer to receive pellets from bucket wheel machines at 3,000 to 4,000 TPH.

5.4 Operating Data

As summarized in Table 2, Allouez Dock #5 consists of an 87 acre (0,3 km^2) facility providing 5.5 million tons of storage capacity in a stockpile area 3.5 miles (5,6 km) from the dock and 72,000 tons of storage in the dock silos. A conveyor system, 5.7 miles (9,2 km) in length, links the 2 rail car unloaders, the 3 stacker reclaimers, and the shiploader. Taconite pellets usually arrive in BNSF trains of 150 cars [each 35 feet (10,7 m) long "H-1" type at 1,800 ft^3 (51 m$^{3)}$ capacity] and are loaded into special lake vessels. Up to 185 car trains can haul

Fig. 26: Eighteen 36 inch (0,9 m) wide conveyors can load lake vessels at Allouez Dock #5 at a rate of 4,200 TPH.

20,000 tons of taconite pellets, at a gross train weight of 27,000 tons. Winter temperatures can reach –30º F (-34º C). Typically, ice does not cover all of Lake Superior, but near-complete sheets of ice, from a few inches to several feet thick, do form in the harbor area of Superior and St. Louis Bays. As early as mid-November and persisting as late as early May, ice in the Soo Locks or the harbor ends the shipping season. Frozen blocks of pellets can be found in the stockpiles as late as August and September. The 75 BNSF employees at Allouez Dock #5 unloaded 537 trains or 79,201 cars in 2003.

Table 2: Alllouez Ore Dock #5	
Annual throughput	14.5 MTPY
Storage Capacity	5.5 Million Tons
Train Unloading Rate	4,200 TPH
Reclaim Rate	3,000 to 4,000 TPH
Shiploading Rate	3,000 to 4,200 TPH
Dock Length	1,400 FT (430 m)
Train Size	150 cars
Max Draft at Dock	27 FT (8,2 m)
Size of Facility	87 acres (0,3 km^2)

5.5 Motorized Pulley Experience

Fig. 27: 4,000 TPH Bucket Wheel Reclaimer in its second season after the 2004 Motorized Pulley upgrade. Note one Motorized Pulley beneath the boom conveyor and two under the tail conveyor.

Engineering Design Services and Rulmeca engineers first presented the Motorized Pulley upgrade concept for the bucket wheel reclaimers to BNSF personnel in 1995, suggesting a "Dual Drive" arrangement for the tail conveyor due to its requirement of 200 HP (150 kW). Allouez Dock had been maintaining the bucket wheel machines without the assistance of the original equipment manufacturer for more than 10 years in 1995. However, the dual drive concept was relatively new at that time and eight years would elapse before the first bucket wheel reclaimer was upgraded.

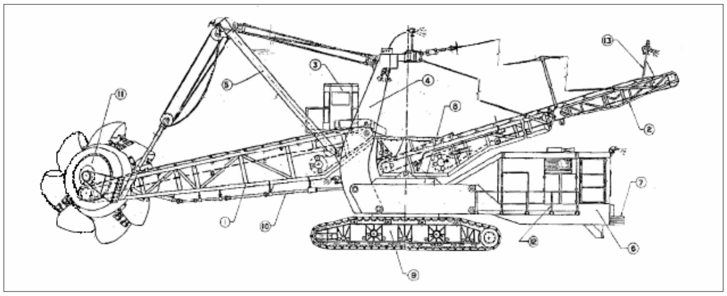

Fig. 28: Original reclaimer layout shows motor and planetary gearbox located between carrying and return strands of 100 HP (75 kW) boom conveyor and 200 HP (150 kW) tail conveyor.

By 2003 original gearbox rebuilds had gotten very expensive. That year three Model 800H Motorized Pulleys, with 31.5 inch (800 mm) diameter and 57 inch (1400 mm) face width were purchased. BNSF operations personnel installed them in 2004. Each Motorized Pulley provided 120 HP (90 kW) at a belt speed of 768 fpm (4 m/s) on a power supply of 460V/3ph/60Hz, generated by the newly-installed on-board diesel generator. The compact design minimized structural modifications and greatly simplified the "Nested Dual Drive" configuration beneath the tail conveyor.

Fig. 29: Rail-mounted stacker reclaimer transfers taconite pellets from rail cars to storage piles and, by reversing its conveyors, receives reclaimed pellets from the crawler-mounted bucket wheel machines. Its hydraulic buffing system enables precise positioning of the boom elevation from –12º to +6º.

The successful upgrade of the first machine encouraged BNSF to upgrade a second Bucket Wheel Reclaimer, completed in 2005, using three 100 HP (75 kW) Rulmeca Motorized Pulleys. The third and final set of Motorized Pulleys was delivered July 2006. Engineering Design Services not only assisted BNSF personnel with initial design to insure a smooth retrofit, Roger Meittunen also traveled to the Rulmeca Motorized Pulley factory in Germany to observe final assembly of the first three Motorized Pulleys and obtain aftermarket service training on the Model 800H units to insure long-term success of the Motorized Pulleys at Allouez Dock.

Fig. 30: Rulmeca technician guides motor/ gearbox as overhead crane lowers 2,000 lb (900 kg) internal components into pulley shell.

6 Escanaba, Michigan

6.1 Synopsis of Upgrade

The Escanaba Ore Dock transfers 8 MTPY of taconite pellets from rail to lake vessels at the Lake Michigan terminal. The Chicago and Northwest Railroad replaced two worn-out Motorized Pulleys on the their bucket wheel reclaimer in 1985, after approximately 15 years of service, when the original Motorized pulley manufacturer went out of business. John Kirkegaard Maskinfabrik A/S supplied the replacement known as “JOKI Motorized Pulleys,” now called Rulmeca Motorized Pulleys. The two 40 inch (1 m) diameter 200 HP (150 kW) Motorized Pulleys are still in service after more than 20 years.

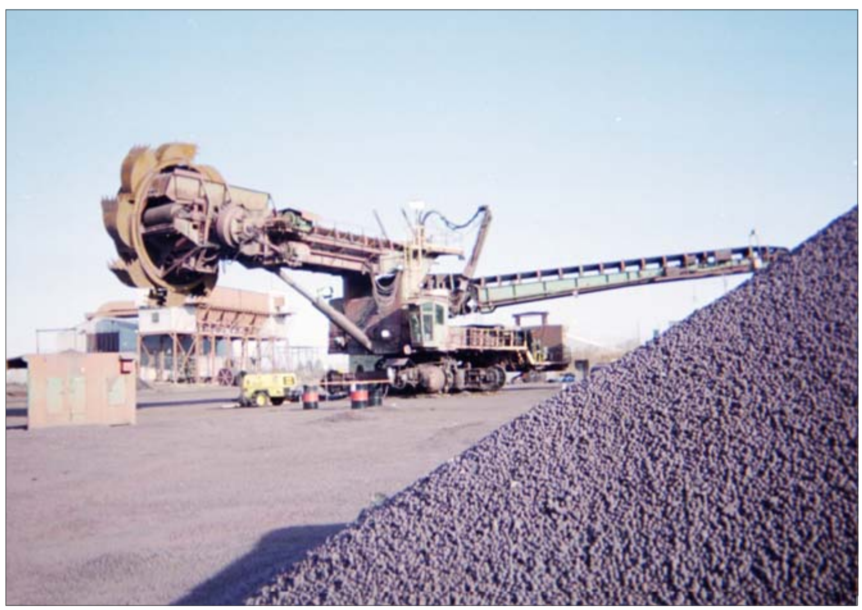

Fig. 31: Rulmeca Motorized Pulleys enable this 27 year old bucket wheel machine to reclaim taconite pellets at 4,000 TPH. Rotary “triple dump” rail car unloader (in background) unloads 150 car trains at 4,000 TPH.

6.2 Objective of Upgrade

The objective of the upgrade was to secure reliable drives for the 4000 TPH reclaimer boom and tail conveyors from an established Motorized Pulley manufacturer with readily available replacement parts. JOKI had been an established brand for 30 years at that time.

6.3 Historical Background

Now owned and operated by CN Wisconsin Central, the Escanaba Ore Dock transfers 6 million tons of taconite pellets from 150 car trains to 37,000 DWT lake vessels each year. Taconite pellets are produced at the Empire and Tilden Mines in the Marquette Range of the Upper Peninsula of Michigan and shipped to steel mills primarily located at the south end of Lake Michigan near Chicago. Iron mining began in the Upper Peninsula of Michigan in 1846. The first railroad connecting the mine at Negaunee with Escanaba was built in 1863 during the Civil War. Prior to the construction of the Ore Dock in 1969 iron ore was dumped

Fig. 33: CN Wisconsin Central 150 car trains carry taconite pellets from Marquette Range 60 miles (97 km) south to Escanaba, Michigan.

Fig. 32: Self-unloading lake vessels as long as 1,000 feet (300 m) move taconite pellets to steel mills near Chicago until freezing water closes the Great Lakes to navigation.

Fig. 34: Traveling shiploader loads pellets into 64,000 DWT lake vessel at 4,000 TPH, filling it in just 16 hours.

Fig. 35: Bucket Wheel boom is hydraulically luffed and transfers 4,000 TPH of taconite pellets on a 60 inch (1,5 m) wide belt at 715 FPM (3,6 m/s).

at Escanaba directly from ore cars into hoppers on the wooden dock and then directly into ships. Built to serve the growing US steel industry in 1969, the Escanaba Ore Dock is now the only taconite ship loading facility on Lake Michigan. The facility set a rail to ship transfer record of 11.9 million tons in 1979. After purchasing "JOKI" Motorized Pulleys in the mid-1980's

Fig. 36: Original Motorized Pulley was removed from service in 1985 when its manufacturer went out of business. Note loose power cord extending from shaft and cooling fins on end housing.

Fig. 37: Rulmeca FAA GmbH has manufactured Motorized Pulleys at Aschersleben, Germany since 1950's.

to replace the original drives, C&NW RR purchased replacement parts from Interroll Corporation in the mid 1990's because Interroll Holding had acquired John Kirkegaard Maskinfabrik in 1988. Interroll subsequently acquired Forder und Antriebstechnik Aschersleben (FAA), a German Motorized Pulley manufacturer, in 1991; closed the JOKI plant in 1995, moving all CNC machines to FAA that year; and sold the FAA plant to Rulli Rulmeca SPA of Bergamo in 2003. Now, the Rulmeca Group serves the original U.S. bulk users of "JOKI" and "Interroll" Motorized Pulleys such as the Escanaba Ore Dock through Rulmeca Corporation, headquartered in Wilmington, North Carolina.

6.4 Operating Data

Currently, each 150 car 10,500 ton ore train makes its 120 mile (194 km) round trip in 12 hours, with three trains arriving at the ore dock each day. A train positioner automatically indexes each train and a rotary dumper unloads three cars at a time at 4,000 TPH. Each year 140 ships, such as the 728 foot (222 m) long 37,500 DWT self-unloading Joseph L. Block, are loaded at 4,000 TPH by the traveling shiploader. The 60 acre (0,2 km^2) facility can stockpile up to 2.5 million tons of pel-

Table 3 Escanaba Ore Terminal	
Annual throughput	8 MTPY
Storage Capacity	2.8 Million Tons
Train Unloading Rate	4,000 TPH
Reclaim Rate	4,000 TPH
Shiploading Rate	4,000 TPH
Max Vessel Size	37,000 DWT
Train Size	150 cars
Max Draft at Dock	31 FEET (9,4 m)
Size of Facility	60 acres (0,2 km^2)

lets with its rail-mounted stacker and crawler-mounted reclaimer, making up to 10 ore blends with the stacker reclaimer equipment. Although ore can be transferred directly from rail to ship, quick turn-around time for lake vessels is essential. Therefore, the reclaimer conveyor drives must be reliable to insure quick stockpile to ship ore transfer.

6.5 Motorized Pulley Experience

The Rulmeca Motorized Pulleys installed on the bucket wheel reclaimer in 1985 are still in service and have now outlasted the original 16 year old pulleys by five shipping seasons. They have enabled the Escanaba Ore Dock to transload more than 150 million tons of taconite pellets during their service life.

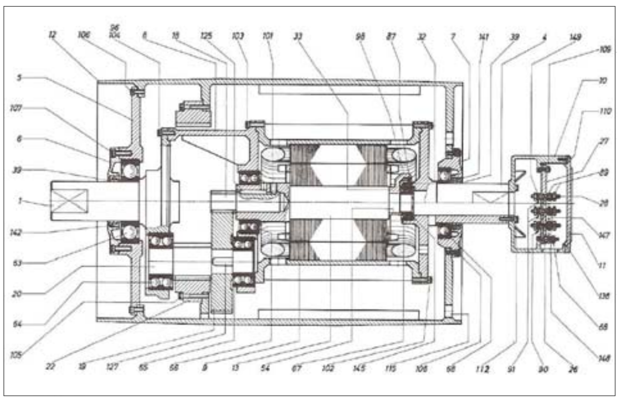

Fig. 38: Drawing shows unique double end housing arrangement on "drive side" of 200 HP (150 kW) Motorized Pulley. Development of different designs and more powerful Motorized Pulleys is in progress at Rulmeca FAA GmbH.

Fig. 39: Engineering Design Services' Roger Meittunen is dwarfed by the bucket wheel reclaimer's huge 40 inch (1 m) diameter 200 HP (150 kW) Motorized Pulley, now in its 21st shipping season.

7 Conclusion

The long service lives promised by large Rulmeca Motorized Pulleys at three major transloading facilities with harsh operating conditions demonstrate the value of Motorized Pulley technology. There are now more than 130,000 Motorized Pulleys, 1 HP (0,75 kW) and larger, in service in North America. Including fractional HP Motorized Pulleys, there are nearly 1 million units in service. A proven design, which hermetically seals its drive system within a compact and oil-filled pulley shell, and a reliable source of supply and after market service will enable conveyor operators and system designers to take advantage of Motorized Pulley technology in North America and the rest of the world for many years to come.

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9 Acknowledgements

Gary Amys, BNSF Allouez Dock #5; Marv Anderson, Krech, Ojard & Associates; Fred Charles, Escanaba Ore Dock; Roger Meittunen, Engineering Design Services; Tim Thompson, Alaska Railroad Corporation.

10 Photo Credits

Alaska Railroad Corporation (1, 5, 6, 8, 9); Jerry Bielicki (2); Tom Carello (33); Scott Carney (22); Duluth Shipping News (23); Engineering Design Services (17, 19, 27, 28, 30); Krech, Ojard, & Associates (7,11); Sam Lapinski (24, 26); Dick Lund (34); Wendell Wilke (32); Colin Keith, Usibelli Coal (5, 8, 9).

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