LOADING LOCOMOTIVE SANDING BINS WITH YOUR FEET ON THE GROUND

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ABSTRACT

Most locomotive servicing facilities include systems that load sand by gravity from towers into locomotive sand bins. Concerns with overhead systems include safety, ergonomics, efficiency, and environmental issues. Operators must climb onto the locomotives to access the towers' bin nozzles and sand hoses. Each hose extends only a short distance along the track, so one set of locomotives must be moved several times to load each bin. In addition, sand towers sometimes release particles into the air and inadvertently dump sand onto the ground. Other options available for filling locomotive bins vary from simple gravity systems to complex (and often proprietary) pneumatic conveying systems.

A pneumatic sand dispensing system constructed at BNSF Railway's Clyde Yard in Cicero, Illinois uses only "off-the-shelf" components, with no proprietary elements required. This pulse-flow pneumatic system consists of a storage silo and pressurized transporter tank to feed dispensing tanks. Hoses on each tank have sanding wands conveniently located next to the fueling systems. Operators dispense the sand safely from the locomotive decks by raising the wands to the nozzles. A lift assist device on each wand allows easy handling of the wands and hoses. Each set of locomotives receives sand simultaneously with other services, thus reducing servicing turnaround time. In addition, the entire system is automated and controlled from a programmable logic controller. Continuous monitoring is unnecessary because the sand flow stops automatically. The completely enclosed system uses a bag house to filter exhausted air.

INTRODUCTION

One of the most prominent features in a railyard is a tall tower with a thin cylindrical tank atop a column of structural steel. Several long hoses dangle toward the ground like tentacles (Figure 1). This fixture, usually the tallest structure in the yard, is known as the Sanding Tower and is a symbol of traditional railroading. The tower's function may be a mystery to the layman, but to the Locomotive Engineer, it is as crucial to getting the 'power' rolling as are the thousands of horses that propel the locomotives.

Sand is as important as diesel fuel to move a locomotive because it provides the critical friction between the steel wheel and rail to start massive trains moving. However, while improvements have been made to fueling systems, most sanding systems still resemble those overhead giants of days gone by. The older systems rely on gravity and an acrobatic operator to dispense sand to the locomotive from above. They are often messy, spilling sand around the sanding area. The sanding tower is usually away from the service track, making it necessary to re-spot the 'consist' in order to receive sand. When time is limited, only the lead engine may receive sand, and the remaining bins will usually have to wait for a later stop.

Several systems are available to convey sand to a locomotive sand box, including combinations of gravity, pneumatic, and mechanical conveying systems. Requirements and recommendations for sanding facilities are covered by Part 6 of the American Railway Engineering and Maintenance-of-Way Association (AREMA) *Manual for Railway Engineering*. Systems range from overhead gravity feed systems (Figure 2) to fully automated pneumatic conveying systems. Some are very complex and expensive, containing proprietary equipment, while others can be completely built and maintained with off-the-shelf items from any source. Some are complex to start up and maintain, while others are more straightforward.

When it is time to update an existing service track and sanding system, or if a completely new facility is being planned, it is important to make an informed decision about the sanding system. All systems and combinations of systems have advantages and disadvantages, and the local personnel must select the type to be utilized if a new system is planned.

Today, pneumatic conveying systems are better understood and much more feasible than in the past. The advantage of pneumatic conveying systems is their ability to bring the sand to the locomotive rather than requiring the locomotive to go to the sand. The experiences of the pneumatic conveying industry, lessons learned by users of similar systems, and recommendations of experts in the field can all be used to design and build a complete pneumatic conveying system with off-the-shelf items including standard vessels and piping.

The Burlington Northern and Santa Fe Railway Company (BNSF) wanted to incorporate a sanding system into its new service platform at the Clyde Yard in Cicero, Illinois. After studying the types of sanding systems currently available on the market and in use by the railroad industry, BNSF had its first pneumatic conveying sanding system designed, constructed, and started up at the Clyde Yard in 2000. This new system was built with no proprietary equipment and was automated and integrated into the service track PLC. The system brought sanding activities to ground level, and sanding is now performed alongside fueling activities, with no need to re-spot consists to receive sand.

SYSTEM COMPARISONS

In this paper, the major distinction between sanding systems is whether the sand is dispensed to the locomotive using gravity or pneumatic conveyance. Although gravity may be used to dispense sand, some sort of pneumatic conveyance is almost always required within a system. Storage vessels upstream of the dispensing hose can be filled by gravity or mechanical means such as a bucket conveyor, but pneumatic conveying is more often used for this application. A comparison of various systems will help to explain how pneumatic conveyance can be better used to suit a facility's needs.

Gravity Flow Dispensing

In the most common system, sand is loaded directly from railcar or truck by pneumatically lifting it 30 to 50 feet into a sand storage silo. Once elevated, gravity becomes the motive force, and sand is dispensed to the locomotive from above. However, safety and efficiency are compromised because of overhead access and re-spotting requirements.

In another type of overhead system, the elevated silo discharges into a hopper located on a gantry crane over the service track. The crane's movement along and across tracks allows for more flexible coverage of locomotives. However, the sand is still dispensed from above. Furthermore, the system includes a crane, hopper, and support elements in addition to the typical sanding tower, potentially increasing the capital cost of this type of system dramatically and requiring significant aboveground maintenance.

Pneumatic Dispensing

Systems that have been adapted to the needs of railroads are available from companies specializing in pneumatic conveyance applications for materials like sand. A transfer tank system (Figure 3) is the most common pneumatic system used to convey sand. In general, sand must be pneumatically conveyed in dense phase flow due to its abrasive, non-permeable properties. Specially configured transfer tanks with proprietary technologies have been developed for specific applications. However, all such systems contain essentially a pressure vessel with a conical bottom and use the following basic steps.

Sand is initially stored in an elevated sand storage silo directly above a transfer tank. When the transfer tank is empty, the valve between the silo and the transfer tank opens. The vent line valve also opens, and the transfer tank is allowed to vent while sand is gravity fed to the transfer tank. The transfer tank is at atmospheric pressure during the fill process. The silo is allowed to vent through a filter located directly on top of the silo.

When the transfer tank is full, the valve between the silo and transfer tank closes. The transfer tank is then pressurized. The material being conveyed is extruded from the bottom of the tank into the conveying line. Some transfer tank systems add additional air at the exit of the transfer tank to break the extrusion into discrete plugs, or pistons. The conveying mode in these systems is known as pulsed-piston or plug flow.

In some systems, sand is stored in a silo and then conveyed by a transfer tank to other smaller dispensing silos located along the service track. Each dispensing silo is equipped with a filter vent and a proprietary transfer tank beneath. Sand is conveyed from the transfer tanks to the locomotive sand boxes. Although this arrangement allows for sanding on the service track, it can be very complex. Multiple dispensing silos, transfer tanks, and filters may drive capital and maintenance costs up.

Boosters are commonly used to inject air into the conveying line at regular intervals to help move the sand along. While it appears to be a good theory, it is nearly impossible to time the movement of the sand pistons in the conveying line accurately enough to inject air at the right time between pistons. Air injected into a piston can split it and cause it to destabilize. Paul E. Solt states, "This range of theories shows that booster use is indeed a great mystery, not only regarding how to adjust air volume with boosters and determine the proper distance between boosters, but regarding what the boosters actually do in dense-phase piston-flow conveying. As a result, it may be better to use boosters to prevent or remove line plugs rather than as a continuous conveying system supplement."(1)

Some railroad companies have taken an innovative approach by purchasing off-the-shelf components to mimic proprietary pneumatic systems.(3) Although these systems are similar to prepackaged systems, they are usually much simpler, and a rail yard can purchase off-the-shelf replacement parts and services from competitive sources. These systems can be built with materials and equipment commonly used at the yard, including standard pipe fittings and valve actuators. They are based on simple, sound pneumatic conveying principles, and can be very economical and effective when they are optimized. This is the type of system that BNSF selected for its new service track at the Clyde Yard in Cicero, Illinois.

DESIGN CRITERIA

With the decision to apply a custom design using off-the-shelf equipment, the design process considered several issues in order to improve the BNSF system over other methods and specifically suit the needs at the Clyde Yard.

Safety

Employee safety is a primary concern of the railroad industry. “Safety First!” has become the motto of the modern railroad employee, and system upgrades always include implementation of engineered controls to improve safety. Overhead sanding systems are a major safety concern even though modern fall protection systems have substantially improved safety. Nevertheless, climbing onto a locomotive is still an unnecessary risk, requiring specialized safety equipment and procedures.

Maintenance

Old sanding towers are often relocated to new service tracks. The articulating knuckle joints on the arms of overhead towers are often the weakest link. They are usually allowed to simply leak sand because replacements are expensive and hard to find. In addition, since sand is usually pneumatically conveyed up to the silo, the fill pipes wear out frequently due to sand abrasion. System maintenance must take place high above the ground with all required safety systems and procedures in place.

Automated pneumatic systems often use valves and operators that will not stand up to the harsh sand environment. The contact of valve seats with the sand is often ignored, and valves must be replaced regularly, contributing to high operating costs. High system operating pressures cause increased wear in the conveying pipe. Multiple air injection solenoid valves for pulse flow provide many additional opportunities for failure.

Complexity

Modern pneumatic conveying systems are often complex, containing proprietary equipment and control logic. These systems may be too complex to set up, tune, and operate consistently without constant help from the manufacturer. Failed components must be replaced with proprietary equipment. Also, these systems often rely on multiple solenoid valves to inject the air necessary to move the sand. The number of failures is likely to increase with the number of moving parts.

Housekeeping

Sand spilled or dust vented from overhead systems creates a mess around the sanding tower. The mounds of sand eventually find their way to the industrial wastewater treatment system. Whether the yard utilizes a simple oil/water separator or a treatment plant, the sand must be separated from the water with additional equipment and hauled away as expensive sludge.

Efficiency

Stationary sand towers slow down the efficiency of new and existing fueling platforms and create a potential bottleneck in the turnaround time of the power entering and leaving the yard. These sand towers are usually located away from the fueling platform. It is futile to make fueling faster and more efficient with better equipment, multiple fueling stations, and well designed fueling platforms as long as the consist must be re-spotted to receive sand. Even when the overhead tower is located on the service track, the consist must usually be re-spotted under the arms of the sanding tower before leaving the service track.

BNSF was constructing a new locomotive fueling facility at the Clyde Yard to be highly efficient, safe, and environmentally friendly. Full fueling and lube oil services are available to the entire consist with a single spot. New counterbalanced fueling cranes and retractable lube oil and water hoses contribute to a safer environment. Fuel crane nozzle drains and a membrane liner under the platform capture fuel for recovery at the wastewater treatment facilities. The sanding system was designed to complement and not impede the improvements incorporated into the new fueling platform. The choice for this system was a positive pressure sanding system with multiple sand dispensing stations.

SYSTEM ENGINEERING DESIGN

Overview

The general elements of a positive pressure sand system (see Figure 4) include:

1. Sand Storage Silo (Figure 5A) filled from truck or railcar. Dry air is continuously circulated in the silo to keep the sand dry and prevent condensation from forming within the silo.

2. Transfer Tank gravity fed from the overhead Sand Storage Silo (Figure 5A).

3. Distribution Tanks (Figure 5B) fed from the Transfer Tank.

4. Sand Distribution Wands (Figure 5B) fed from the Distribution Tanks to fill the locomotive sand boxes.

5. Distribution Piping between the Transfer Tank and Distribution Tanks.

6. Venting System to relieve pressure from the tanks prior to and during filling.

7. Bag house to collect fugitive emissions of sand and dust from venting tanks. The bag house fan operates unless all system vent valves are shut.

8. Air Compressor and Desiccant Air Drier System.

9. Miscellaneous valves, controls, and level and pressure sensors.

10. Programmable Logic Controls (PLC).

The Sand Storage Silo must be filled from a truck equipped with an onboard transfer system. The Silo is vented to a bag house through vent piping, so that no fugitive dust emissions are carried into the atmosphere by the air being displaced from the silo during the fill process. The sand is stored in the Silo in a dry air environment until a system cycle is initialized. The cycles are initiated when the Distribution Tanks are empty and call for sand.

When a Distribution Tank requests sand, a valve on the vent line from the Transfer Tank opens and allows the Transfer Tank to vent. The fill valve between the Transfer Tank and Sand Silo opens and allows the Transfer Tank to fill. The fill valve closes when the instrumentation indicates that the Transfer Tank is full. A solenoid valve then opens on the air supply line, allowing dry compressed air from a dedicated air system to charge the Transfer Tank to the system pressure through a critical flow orifice.

As the system pressure increases, both the fill valve and the vent valve at the Distribution Tank requesting sand are opened. Sand is then extruded from the blow tank as discrete pistons into the distribution piping and delivered to the depressurized Distribution Tank. The fugitive dust from the Distribution Tank fill process is vented through the Distribution Tank and into the vent piping. When a high level is sensed in Distribution Tank, the fill valve and the vent valve close.

Once the Distribution Tank is filled and the valves are closed, dry compressed air charges the Distribution Tank to the dispensing pressure and locomotive sanding can take place. If the pressure in the Distribution Tank drops when locomotive sanding is not occurring, a leak in the system is indicated. The leak is most commonly found in the fill and vent valves. If a low level is indicated in the Distribution Tank, a new system cycle is initiated.

Each Distribution Tank is equipped with four Sanding Wands (Figure 5B) consisting of high pressure blast hose and aluminum tubing. The aluminum has better wear properties and is much lighter than steel, making it easier for the operator to manage. The Wand discharge end is U-shaped, which allows it to be hooked over the lip of the locomotive sand box nozzle. Each wand also has a small hook at the sand discharge end that is used to lift open the lid of the sand box.

To use a wand to dispense sand, the operator reaches up to grasp the wand, extends the cable and hose to the locomotive, and hooks the wand over the locomotive deck railing (Figure 6A). After climbing to the locomotive deck, the operator reaches the wand up to the sand box fill nozzle, opens the cap with the wand, and places the end of the wand in the nozzle. To begin sanding, the operator simply opens the ball valve that is installed at the hose/wand connection. Flow stops automatically when sand covers the outlet of the wand. The ball valve is then closed and the wand is shaken to release residual sand into the box.

Theory and Principles

The sand in this type of system is conveyed in a special form of dense phase conveying, known as pulse piston flow. A detailed description of the theory and equations used to model such a system are not discussed here. For more information on this type of system, as well as more general information on pneumatic conveying, Paul E. Solt's "Pneumatic Points to Ponder…" which appears regularly in *Powder and Bulk Engineering*, is recommended. David Mills' text, *Pneumatic Conveying Design Guide*, is also a useful reference.

Improvements

System Components and Operation

Similar off-the-shelf systems and packages available from pneumatic conveying equipment companies were studied during the design process. Recommendations from texts and experts in the field of pneumatic conveying were also considered. As a result, many improvements over existing systems were included in the design and configuration of the new sanding facility at the Clyde Yard in order to provide a more robust, reliable system. Some of these improvements are summarized below.

System Supply Air

A critical flow orifice was utilized instead of a pressure regulator for the transfer tank supply air. A common misconception regarding pneumatic conveying systems is that pressure is the driving force to convey the material. The amount of sand conveyed is actually related to the amount of air entering the system. The system pressure is simply the resistance of the sand to moving through the system. Solt states, “the conveying phase and material movement through the line are functions of airflow, and air pressure is the result of resistance to airflow.”(1) Use of a pressure regulator to supply air to the transfer tank limits the operation and flow of sand to the system pressure set point. The critical flow orifice allows better control over the amount of sand being conveyed. It also allows the system to be tuned and optimized to operate at the minimum required system pressure.

Since boosters were recommended to purge the line rather than to attempt to boost the flow, the booster control logic installed in the Clyde Yard system was changed. Rather than attempting to time the boosters with the movement of the sand, use of the boosters is tied in with the system pressure as read at the Transfer Tank. Increase of the Transfer Tank pressure above the system’s normal operating pressure indicates a blockage in the system. The boosters are allowed to operate to clear out the blockage. When the system pressure returns to normal, the boosters are shut off. The use of the boosters in this way has been very successful.

Storage

Atmospheric conditions in the Chicago area are notoriously hot and humid during the summer months. Sand attracts the condensation that can form on cool metal surfaces, and clumps, making its flow from the Silo to the Transfer Tank difficult, if not impossible. A blanket of cool, dried, instrument-quality air is supplied to the air space in the storage silo from the same system that provides the conveying air to the rest of the system. This helps to keep the atmosphere in the silo dry and in turn minimizes the amount of water that is available for the sand to absorb.

Vertical flow of materials such as sand from storage silos can be problematic. Even though the silo bottom may be designed with a properly configured hopper, flow from the silo can be interrupted. Bridging and ratholing are the most common causes of this problem. In bridging, the material packs tightly around the exit nozzle and causes an arch to form, preventing the material above the arch from falling. Ratholing results when material does not move toward the center of the silo. Stagnant material on the sides compresses and becomes resistant to flow. Only the material in the middle directly above the nozzle flows, causing a long hole down only the center of the silo. Since only a small amount of material actually moves, not all of the material in storage can be used. Many flow aids are available to keep material moving in the hopper section of a silo. These include vibrating bin activators, shakers, external side wall vibrators and impactors, and air cannons and infusion devices. Since a supply of dry, compressed air was available, an air infusion flow aid was utilized at the Clyde Yard to help ensure a steady, uninterrupted flow of the entire volume of sand through the silo. Small air infusion nozzles were spaced around the hopper to inject air between the Silo wall and the stored sand while the sand discharges to the Transfer Tank.

Valves and Operators

The choice of operated valve is crucial to reliable system operation. These valves must be able to close against the system pressure while handling the harsh, abrasive conditions of flowing sand and dust. Ball valves and plug valves rely on movement over a valve seat. The sand can easily foul this type of valve and cause the valve to seize, frequently causing the operator to shear the valve stem. Rubber-sleeved pinch valves were selected for the distribution line and vent line block valves because a valve seat does not contact the material. The rubber stands up much better to the friction of the passing sand. A valve failure can be indicated when a wire inserted into the rubber sleeve breaks due to wear of the rubber, causing an open circuit. Another advantage of this type of valve is that only the sleeve, not the whole valve, requires replacement. The operator utilizes system air and is pneumatically actuated, thus minimizing the size of the operator and simplifying actuation.

Pipe and Fittings

Sand flowing through a pipe will cause the pipe to wear. Experience has shown that pipe wear occurs most commonly in specific locations in the system. These include small distances past changes in direction. Flanged pipe spools were installed at these common wear points to simplify the replacement of worn pipe. The worn out section can be unbolted quickly and a prefabricated replacement installed, minimizing down time.

Pipe fittings also wear out. The type of pipe fitting to use at changes in direction is a highly debated topic. Specialized fittings are available that are purported to minimize wear at changes in direction. However, most systems conveying abrasive materials utilize either two 45-degree wye fittings or a tee to change direction 90 degrees. The extra leg of the wye or tee is blind flanged, allowing sand to build up in the "dead leg." While the sand moves through the change in direction, the sand wears on sand, rather than on the outside radius of a steel fitting such as an elbow. Tests have shown that the pressure drop through a tee is less than the pressure drop through two wye fittings. The single tee fitting also experiences less wear, because the sand changes direction only once. It has been shown that a blinded tee bend has up to 15 times the life expectancy over a large radius bend.(2) The blind flange of the tee can also be removed, making a convenient cleanout point. Tees were therefore utilized for all 90-degree direction changes at the Clyde Yard.

Pressure Vessels

Proprietary transfer tanks were not utilized for the system at Clyde Yard. The Transfer and Distribution tanks are simply ASME code pressure vessels with the appropriate process connections. The nozzle for the distribution piping on the Transfer Tank can be located either at the bottom of the tank, or on top of the tank with a pipe extending to the inside bottom of the tank. The top outlet method was utilized with a dip tube sleeved inside the Transfer Tank outlet nozzle, allowing most of the wear to occur on a replaceable part instead of the vessel wall. Handholes were also provided in the tanks for cleanout purposes.

Safety and Ergonomics

Integrating a sand conveying system with the other track-level dispensing equipment improves safety by reducing locomotive movement in the yard. Track-level dispensing minimizes operator movement on and around the locomotive, further improving safety. This section describes how safety and ergonomics were improved by utilizing a positive pressure sand dispensing system.

The locomotive fueling cranes at the Clyde Yard are spaced at 45 feet, which is set by the reach of the articulating fueling crane. Retractable lube oil and water service hoses are spaced similarly. Of the platform services, fuel tank fill nozzles are located closest to track level and fueling is conducted completely from the platform. Lube oil and cooling water fill ports are accessed from the deck level along the side of the locomotive. The operator can climb to the deck, reach the hose reel within a boom rotated toward the deck, and then extend the hose. Sand bin nozzles are located highest with no surrounding hand rail system. To give sanding a feel similar to other services, the following criteria were established for sand stations:

1. Provide necessary reach to match fueling and lubing spacing.

2. Access hose at platform level or via deck from behind hand rail.

3. Insert end of dispensing nozzle into bin nozzle with feet on solid footing behind railing.

4. Reduce effort required by the operator to lift and extend hose and wand.

Additional criteria included:

5. Limit interference of sanding hoses with other operations.

6. Minimize the length of sanding hose and improve safety of stowed hose.

7. Use off-the-shelf components.

The best dispensing system was considered to be hose festooned from an overhead trolley that travels along an overhead I-beam rail (Figure 5B). The wand is supported by a cable that can be extended and retracted on a spring-loaded spool. The apparatus allows the wand and hose to be extended along the service track on the I-beam. When stowed, the trolleys are located directly above the distribution tank and the hose hangs vertically with the wand suspended slightly overhead and hooked to the distribution tank. The spring tension on the spool can be adjusted to vary the force associated with extending the cable. The tension was set so that the cable completely rewinds when the wand is released, but undue force is not required to unwind the cable.

To achieve the desired reach, the three dimensions of the reach were considered: distance parallel to track from distribution tank to sand box, distance from center of platform to center of tracks, and vertical distance from hose trolley down to sand box. The length of hose from the tank outlet to the overhead support is approximately 3 feet longer than the distance between the two points. The extra 3 feet allows the trolley to extend approximately 12 feet from the tank, and the extra hose can be safely stowed close to the tank (Figure 5B). From the hose carrier, the wand must reach approximately 13 more feet along the track, approximately 11 feet down to the lowest nozzle, and 10 feet out to the centerline of the track. The required length of hose is approximately 20 feet, including hose droop and the length of the wand. Since the hose carrier is located 21 feet above the track, the hose does not drag on the ground when stowed. The design allowed for approximately 30 feet more than eventually required to allow for required field measurement and adjustment of the hoses.

Startup and Automation

The Clyde Yard design included multiple components to allow for nearly complete automation. In addition, the system design accounted for the inability of pneumatic conveyance modeling to accurately predict sand flow rates for pulsed piston flow. The system was slightly over designed to allow operation in a prototype mode during startup with only a basic PLC program. As the system characteristics were revealed, the automation and program were optimized.

Initial programming and testing included input/output (I/O) checks, valve cycling and timing, and compressed air system and bag house startup. Next, the sand silo was filled and the air purge system placed on line. With the components checked and peripheral support equipment operating, the system was ready to convey sand. Sand conveyance tests were conducted in the following sequence:

1. Fill transfer tank and record fill time.

2. Activate boost system and verify boost air flow.

3. Align valves to fill each distribution tank one at a time. Pressurize transfer tank and monitor pressures and record time to fill each distribution tank.

4. Pressurize distribution tank and monitor flow as a function of pressure.

In the interest of time, only gross adjustments were made that ensured reasonable system operation. However, the inclusion of PLC control allows for detailed system analysis and testing to provide empirical data to improve modeling of sand media. Visual and aural observations were also valuable during startup.

Initial fill rates for the transfer tank from the silo were observed to be slower (~1 hour) than expected (<30 minutes). Due to a previously undiscovered pipe misrouting, no vent path was available during gravity flow of sand from the silo. Once this problem was discovered and corrected, the transfer tank could be filled from the low to high-level switch (~130 cubic feet) in less than 20 minutes.

Other approximate values observed during startup and calibration are listed below.

- Transfer tank operating pressure: ~60 psi filling closest distribution tank via ~200 feet of piping. ~100 psi filling farthest tank via ~425 feet of piping.

- Distribution tank low-to-high fill time: Closest tank ~20 minutes. Farthest tank 45 minute to 1 hour.

- Sand flow rates: Closest ~4 ft^3/min = ~400 lb/min. Farthest ~1.5 ft^3/min = ~150 lb/min.

Flow rates for the wands are very sensitive to pressure. Flow was sluggish at 40 psi in the distribution tank. At >50 psi, the wands were difficult to handle and significant air entrainment occurred. The optimum dispensing pressure for the Clyde Yard system was found to be ~45 psi, at which the sand flowed at roughly 1 ft^3/min.

The PLC was programmed to establish the following priorities:

- Transfer tank filling overrides all other functions.
- Distribution tanks can only be filled one at a time. If the distribution tank receives a request to be filled, either by manual pushbutton or low-level switch, the vent valve opens immediately. The fill valve does not open until all other distribution tank fill valves are closed.
- The PLC is programmed to prioritize which tank fills first when two or more tanks are venting and waiting for another tank to finish filling.
- Neither the pressurization solenoid valve nor the fill valve can be opened when a low level switch is locked in.
- Each tank has a maximum fill time based on the values reported above.
- The transfer piping air pulse solenoids operate in series from the distribution upstream to the transfer tank to clean out the piping prior to transfer tank pressurization.
- During sand transfer, loss of pressure in the transfer tank indicates that it is empty, and 30 seconds of sustained pressure loss initiates the transfer tank fill cycle from the silo.
- If the PLC malfunctions, the system can be operated manually.

CONCLUSIONS

The positive pressure sand system installed at BNSF's Clyde Yard allows multiple sand dispensing positions and any bin on any locomotive in a consist to be filled while it is receiving other services. Most importantly, the operator's feet never leave the deck of the locomotive to dispense the sand. In addition, if any system component fails, replacement parts are available off-the-shelf from local suppliers. The system is highly automated, with sand available for dispensing at a moment's notice. Although many other types of sanding systems are available and work well, the advantages of a positive pressure sanding system made it the right choice for BNSF's Clyde Yard.

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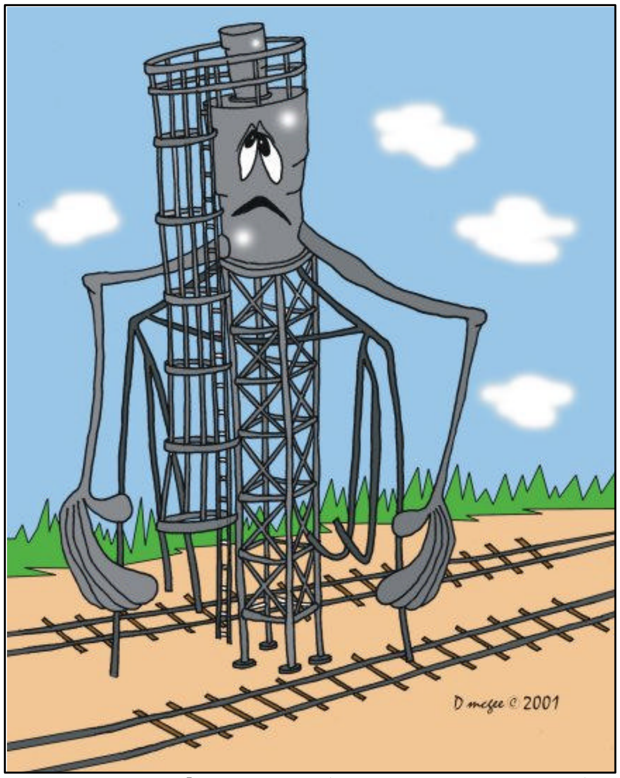

Figure 1 – Sanding Tower (©2001, Dave McGee)

Figure 2 – Gravity Sanding Tower, BNSF Whitefish, MT

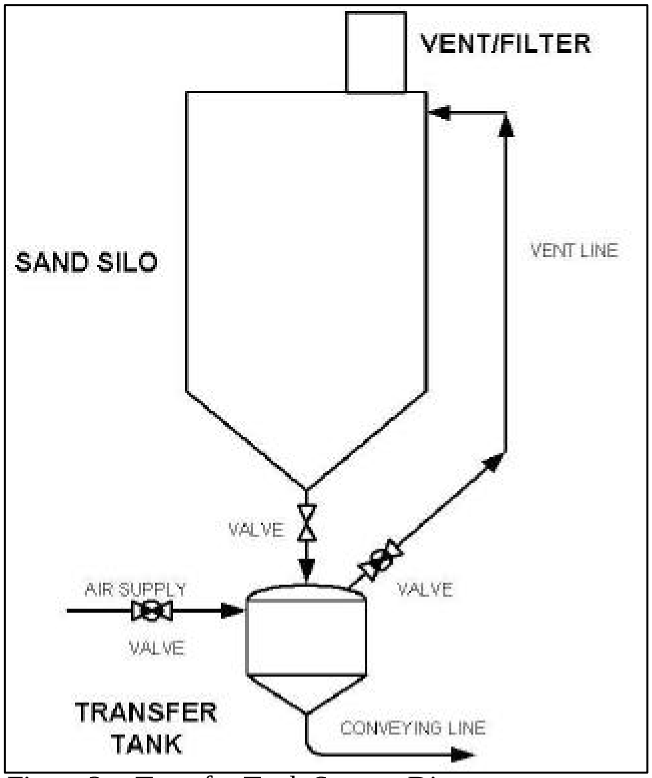

Figure 3 – Transfer Tank System Diagram

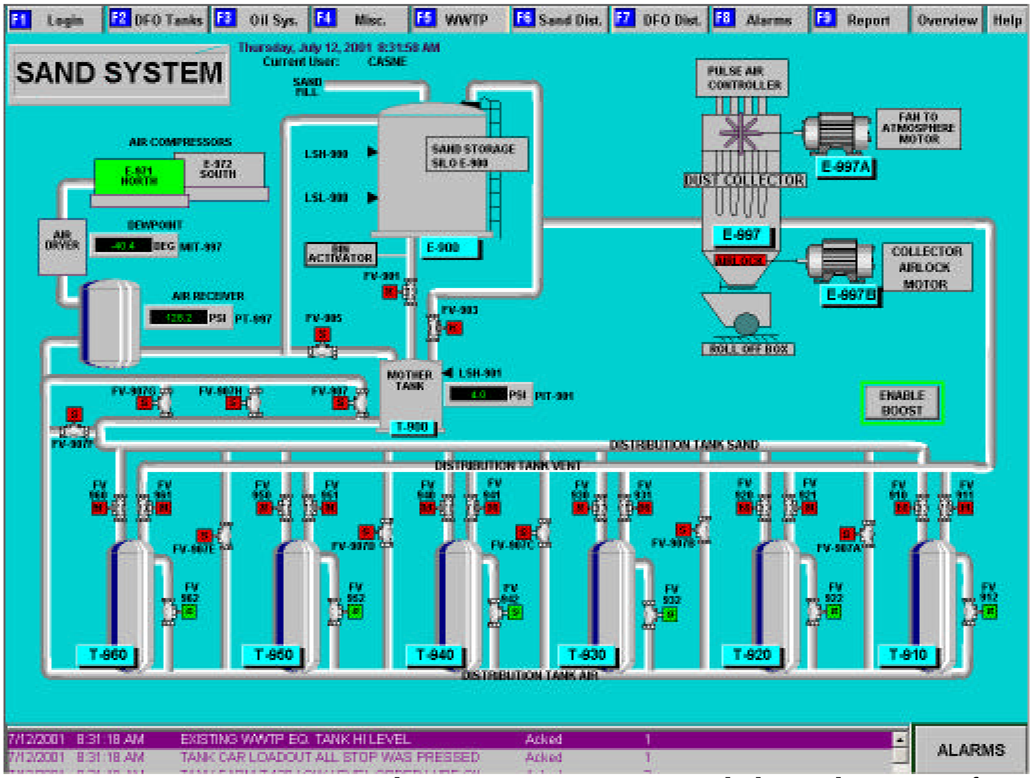

Figure 4 – Positive Pressure Sand System Diagram, BNSF Clyde Yard PLC Interface

Figure 5 – Major Components (A) Sand Silo and Transfer Tank, (B) Distribution Tank and Wands

Figure 6 – Sanding a Locomotive. (A) The operator hooks the wand on the locomotive rail. (B) From the locomotive deck, the operator opens the nozzle lid, retrieves the wand from the rail, and hooks the wand into the nozzle. The tip of the wand is initially rested on the nozzle (Step 1). The operator then lifts the grip until the end of the wand drops into the nozzle (Step 2). When the grip is released (Step 3), the end of the wand wedges securely, extending several inches into the box. The operation is reversed to remove the wand.

LIST OF FIGURES