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LA-UR--91-2790

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SUBMITTED TO American Glovebox Society Annual Conference and Equipment Show
Nashville, TN
August 26-29, 1991

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DESIGN AND USE OF SNM TRANSPORTATION SYSTEMS AT THE LOS ALAMOS NATIONAL LABORATORY

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The Plutonium Processing Facility at the Los Alamos National Laboratory is located in a building containing approximately 63,000 square feet of laboratory space with an additional 63,000 feet of basement area that is used for heating, ventilation, filtering, storage, and other "house" systems. The building's upper floor, (laboratory area), is set up in four separate wings with different types of processing occurring both within each wing and between the wings. Because of the diversity of these various processes, material must be moved within and across the various wings. Special Nuclear Material, hereafter referred to as SNM, must always be handled in an enclosed container in order to protect the environment and the workers who are using the material. In order to avoid making repeated transfers of material by an external means, LANL has designed a system whereby most of the wings and rooms in the Plutonium Facility are interconnected by a series of tunnels through which a transportation system or "trolley" operates. This tunnel serves a dual purpose in that it also supplies dry air to the gloveboxes. The tunnels extend the entire length of the building in each wing making a total of four tunnels with an additional tunnel installed such that it connects all four wing tunnels to each other. It can readily be seen that this also creates a problem in that a "chimney" now exists which can cause a fire to spread rapidly from one line or area to another. LANL has designed a series of air and mechanically operated fire doors that are located throughout the tunnel system to prevent this occurrence from happening. Double dropboxes are located at the end of each wing tunnel where the cross tunnel connects. Here, material can be off loaded from a wing trolley and on loaded to the cross trolley for further movement to any other area where it may be needed.

The transportation system for SNM is fairly complex and several factors must be considered in its design. Safety of the personnel who will be using the equipment, how well the equipment performs the job for which it is intended, how reliable it is, and how maintenance free it is are all important factors in designing any kind of automated equipment. All these factors were incorporated in the LANL trolley systems making them among the best in the industry.

Being that the tunnel system is so long, it is evident that more than one trolley is necessary per tunnel. With several different processes going on at the same time in any one wing it would be extremely inefficient to delay operations in any one area while waiting for the trolley to become available. LANL uses two to three trolleys per tunnel to eliminate this problem. This does require the off loading and reloading of material if it is being moved the entire length of the tunnel; but, since the majority of movement is within one particular type of process, this is not a major concern. The total length that the trolleys must travel is anywhere from 75 to 125 feet. It can readily be seen that the speed of the system must be such that it can travel from one limit to the other in a reasonable amount of time. LANL's system uses a magnetic sensing switch arrangement to inform the computer of location and mode in which the trolley is at any one time. The trolley initially travels in a high-speed mode and then automatically goes into a slow speed mode shortly before reaching the station it has been called to. The computer is programmed such that all contacts actuated by the permanent magnet on the trolley carriage are ignored except for the one at the station it is called to, whereupon, the first sensor switch causes it to go into slow mode and the second makes it stop at the station.

Upon reaching a particular station, the trolley must incorporate some device to keep it from being called to another station before the original station has completed operations. Our system incorporates a "hold" feature that accomplishes this. Upon reaching a station that has been called, the trolley locks into "hold" for a predetermined, (settable through the program), period of time. Secondly, upon the lowering of the trolley bucket, a microswitch engages which locks the system in "hold" the entire time that the bucket is away from the carriage. This feature prevents the trolley from moving toward another station while dragging the bucket along behind it. Additionally, a manual hold switch is located on the station controls at the drop station which will maintain the "hold" feature as long as the manual switch is in the depressed mode.

The bucket of the LANL system is lowered and raised through a system using a one-piece aircraft cable and rotating drum arrangement. One end of the cable is hooked into the drum, then threaded through two pulleys on one side of the bucket-hoist assembly, back up through two more pulleys located on the underside of the main trolley, across a down limit microswitch, through two more pulleys, back down to the opposite side of the bucket-hoist assembly and through its two pulleys, then back up to the opposite hole in the drum. This adds to the stability of the bucket during lowering or raising operations because it works the same as a four-part cable, with each cable supporting one corner of the hoist assembly. The cable can be installed without using tools as the only item that needs to be removed for cable installation is a series of quick-release pins. A down limit switch is incorporated in the hoist-operation mode to prevent cable "backlash" if the bucket were allowed to contact the floor of the dropbox or any items directly under it. When the bucket contacts anything while being lowered, a microswitch engages, which in turn opens the contact between the down button and the hoist motor causing the drum movement to stop while some tension is still on the cable. A second microswitch is located in a position that will stop the drum movement in the upward direction whenever the bucket arrives at its top limit. This switch will deactivate the up-switch and keep the hoist motor from continuing to run in the stalled mode, causing excessive stress on the cable and eventual breakage. The next generation of trolleys will also incorporate a slip clutch on the hoist motor that will prevent cable breakage. A brake assembly is used with the drum to allow the load to be locked in the up position while it is being transported through the tunnels. This brake not only locks the load up but also applies drag when the hoist is being lowered. This feature prevents the hoist drum from "freewheeling" down at an uncontrolled rate of speed. This brake is applied by the use of a ramp assembly and a ratchet wheel with a spring loaded pawl. Other design features of the hoist part of the trolley include an extra deep groove in the drum, a tightly fitted cover over the top side of the drum, and a unique cable-to-drum attachment all of which help prevent inadvertent backlashes.

As with all systems, Murphys law is alive and well in ours. The computer can and does occasionally lose its mind and loses track of the trolley's last location. When this happens, the trolley can run in either direction and will not shut off automatically. To prevent the carriage from going to the end of a line and continuing to run in the stopped position, our system incorporates microswitchs on each end of the carriage assembly that will deactivate the motor from the computer. This switch inserts an automatic hold command which can be reset by simply calling the trolley to another station in the opposite direction from which it last traveled. We also incorporate a slip clutch on the motor drive pulley that allows slippage in case the microswitch fails.

There are many ways to keep the trolley carriage assembly aligned on the travel rails. LANL's original system used cam followers which turned out to be extremely noisy and required grease yearly. The present systems uses a grooved wheel that has a polyurethane tread cast in the bottom of the groove. This has resulted in nearly silent operation and reduced maintenance.

To make maintenance easier, all the motors, gear reducers, and the drum are located on top of the carriage assembly. The drum is mounted using "C" clamps around bearings to ease the task of changing brake discs or bearings. Special lift tools are mounted next to the drum for use during removal as there is no other way to grasp it. The drive axle is also made in three parts to simplify bearing changes that may be necessary. This design allows for a bearing change without removing the carriage from the tracks. All bearings are sealed and need no lubrication. The gear reducers are the only items on the trolley needing lubrication and require only a yearly check of the fluid levels.

The electrical power and "brains" to operate the LANL system is provided through an Allen Bradley PLC-2 series programmable controller. This controller is very easy to program through the use of a personal computer. Logic is set up through a ladder diagram of latched and unlatched relays that can be used in a nearly infinite number of combinations. This makes possible the use of external microswitchs in combination with internal timers and relays that will either allow or prevent various operations to occur in whatever sequence one chooses. Next to each dropbox there is a trolley control station with a series of push buttons which allow the trolley to be called from any one station to any other station, an up and down hoist button that allows operation of the hoist in only the station that the trolley is presently located, a hold button that can be used to prevent the trolley from being called to another station, and an emergency stop button that allows any trolley operation in progress to be stopped in the "hold" mode for whatever period of time has been set in the program. If it is necessary to keep the trolley in the "hold" mode for a longer period of time than that allowed by the program the manual hold button should be engaged. There is also an indicator light that comes on when the trolley is in either the "run" or "hold" mode. A maintenance station is located in each area where a trolley operates. Next to this maintenance station there is also a trolley control box that circumvents all the logic circuitry. This control allows movement of the trolley carriage from left to right and vice versa in the slow speed mode only. Additionally, there is an up and down switch for the hoist that will operate regardless of limit switchs. The input and output cards and registers of this controller are protected by a fault monitor system which prevents damage that can be caused by large voltage spikes and shorts.

Problems that LANL has experienced with its SNM transportation systems include the following.

In some areas of the plant the processes require use of various types of strong chemicals. The air process is set up such that the dry air is delivered to the gloveboxes through the tunnels, out the top of the gloveboxes through a HEPA filter, into the Zone 1 ventilation system, and then through another series of HEPA filters before being exhausted. In many cases the HEPA filters on top of the gloveboxes plug rapidly, or the chemical fumes are concentrated enough that they back up into the trolley system, thus, creating an extreme corrosion problem. When the Plutonium Facility was first opened, the bus-bars through which electrical power is delivered to the trolley were made of zinc- coated steel. Of course, the heavy chemical fumes attacked these bus-bars and rendered them useless in a very short time. LANL has since changed these bus-bars to copper ones that have a stainless steel sheathing formed around them. These bus-bars have been in use for over 10 years and are performing quite well. Other problems have included frequent cable breakage, simple operator misuse, failure of limit switchs, items falling off the trolley and then left in the tunnel, poor design of tunnel systems and maintenance stations, and people in various areas installing equipment right in front of the workstations used for trolley maintenance. Most of the problems that are mechanical in nature have been solved by new designs. More attention is being given to the training of personnel to try to alleviate the problems that are human in nature.