DRY SPENT FUEL CASK TRANSPORTER EQUIPMENT DESIGN, TESTING, AND OPERATIONAL FEATURES

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ABSTRACT

The United States Department of Energy (DOE) has established a program for the testing of a variety of dry spent fuel storage casks. The program is being conducted at the Idaho National Engineering Laboratory (INEL) by EG&G Idaho Inc. Testing of storage casks at INEL requires that large storage casks (max. gross wt. 127.1 Mg) be moved and positioned from/to an indoor loading location to an outdoor storage pad. A Dry Spent Fuel Cask Transporter has been developed to safely, conveniently, and economically transport/handle a variety of storage casks within and around the confines of nuclear sites and facility.

INTRODUCTION

Early in the storage cask program, it had been determined that lifting, transport and general handling of the storage casks would be a laborious and costly task. It was concluded that a cask transporter capable of interfacing with a variety of storage casks would be a more cost effective approach than crane handling and truck transport at the INEL facility.

In September 1986, EG&G Idaho contracted with Nuclear Packaging Inc. (NuPac) for the design, fabrication, testing, and start-up of a dry spent fuel storage cask transporter.

The transporter system developed by NuPac (See Fig. 1) is a U-shaped frame, rubber-tired trailer designed to straddle and hydraulically lift various storage casks. Mounted on tall columns above the trailer frame is a lift beam support structure and hydraulic cylinders. Two lift links are utilized to connect the lift beam to the cask. An onboard hydraulic pumping unit provides the hydraulic power to raise and lower the lift beam. The Cask Transporter is designed to accommodate a storage cask which is 2.66 meters in diameter (max.), 6.09 meters high (max.), and 127.1 Mg (max.).

EQUIPMENT DESCRIPTION

The Cask Transporter is designed with the following primary systems/components:

- Cask Transporter Assembly
- Steering System
- Cask Lifting System
- Cask Restraint System
- Brake System
- Control System
- Hydraulic Power Supply

CASK TRANSPORTER ASSEMBLY

The Cask Transporter Assembly is a carbon steel structure comprised of lower deck and an upper frame. The lower deck is mounted on six wheel assemblies and houses the steering mechanism/towing bar assembly. The lower deck is U-shaped to allow the Cask Transporter to straddle various sizes of casks during lifting, transporting and lowering operations. A cask restraint system is mounted on the top front of the lower deck.

The lift beam support structure is mounted above the lower deck by four columns and contains hydraulically actuated cylinders under a lift beam which hoists the cask.

A personnel work platform area is provided on the upper support structure guarded with handrails and safety chain. The checkered plate work platform has four access panels which are hinged up to allow installation/removal of the lifting links. A personnel ladder is provided at the left rear of the Cask Transporter for convenient access to the lower deck and the upper frame in order to support operation of the Cask Transporter,

The Cask Transporter is constructed primarily as a welded structure with a minimum number of bolted joints to facilitate disassembly for transportation to the users work site. The upper structure is bolted at the four support columns, and the columns are bolted to the lower deck. The lower deck is divided into two halves (each containing three wheel assemblies) with bolted joints at the tow bar assembly and the two structural beams which join the left and right halves. The entire Cask Transporter can be shipped to the work site on three, legal weight and width, 13.7 meter long flatbed trailers (see Fig. 2).

STEERING SYSTEM

The steering system is comprised of the following components:

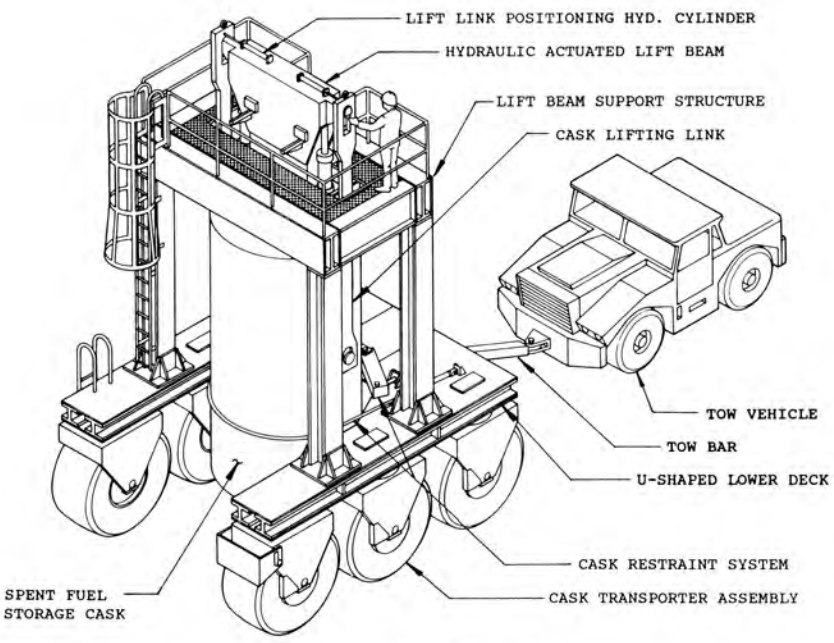

Fig. 1. Dry Spent Fuel Cask Transporter.

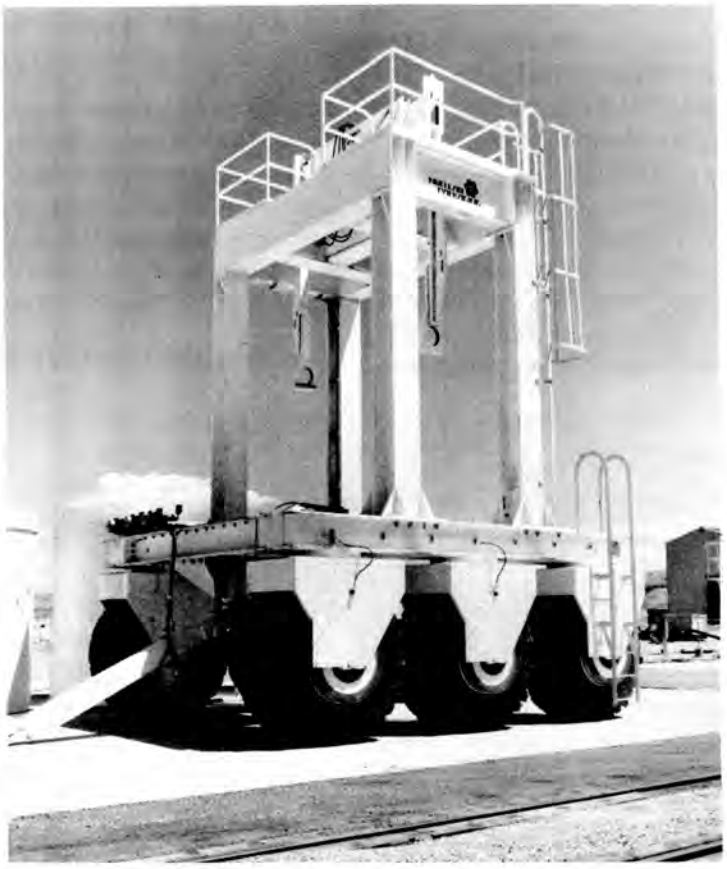

Fig. 2. Cask Transporter Assembly.

- Steering Linkages
- Wheel Assemblies
- Tow Bar Assembly

The Cask Transporter is designed to have a minimum turning radius of 9.15 meters (30 feet) for maneuvering around on- site obstacles and mobility in confined workshops. The steering system is comprised of compensating mechanical linkages joined together to steer both the front and middle pairs of wheel assemblies, directionally operated by the swing of the tow bar. The rear pair of wheel assemblies is stationary. In order to accomplish this short turning radius without major tire scrubbing, the steering system is developed in accordance with Ackerman steering geometry, very similar to automobiles, whereby all wheels are turned about a common center point. During a sharp turn all four steerable wheel assemblies turn at different angles varying from 31 degrees at the front inside wheel, to 11 degrees at the outside middle wheel. The steering linkages are constructed of 7.6 cm diameter heavy wall carbon steel tube connected to turning bulkheads at each wheel assembly. The steering linkages are totally enclosed within the structure of the lower deck.

The Cask Transporter is supported on six wheel assemblies, three on each side. The wheels are all steel rims mounted with heavy duty steel belted radial earthmover tires. The tires are foam filled for purposes of safety, maintenance, and overall reliability. At the vehicle design gross weight of 179.7 Mg the tires have a loading of 29.95 Mg each, with a road bed pressure of 586 kPa. Each wheel is fitted with a pair of roller bearings on a 12.54 cm diameter axle, and then mounted into support casters. The two rear support casters are mounted fixed to the transporter lower deck and the four remaining support casters are mounted with 86.4 cm diameter steering turntable bearings to the lower deck.

The tow bar assembly located at the lower front of the Cask Transporter deck is designed to pull the loaded transporter and operate the steering system. The tow bar is a 25.4 cm square structural tube extending 2.3 meters forward. A steel plate with a 7.8 cm diameter hole is provided at the end of the tow bar for connection to a site supplied tow vehicle. Vertical motion of the tow bar allows for varying hitch heights and for negotiating uneven terrain. A tow vehicle capable of providing 178 kN of pulling force is required to pull a fully loaded Cask Transporter up a 5% maximum grade at 8 kph.

CASK LIFTING SYSTEM

The cask lifting system mounted on the upper frame contains the following features:

- One Piece Lift Beam
- Link Positioning Cylinders
- Security Bars
- Lift Cylinders
- Lift Links

The system is actuated by two double acting hydraulic lift cylinders with a 25.4 cm bore and a 50.8 cm stroke. The hydraulic cylinders are fitted with counterbalance valves which lock the cylinders in place in the event of sudden loss of hydraulic pressure. A second means or securing the raised load is provided in addition to the counterbalance valves. Two 7.2 cm square steel security bars are inserted through the raised lift beam to provide a mechanical block in preventing the lift beam from lowering.

Specially designed lift links are utilized to connect the lift beam with the cask lift trunnions. In use, the lift links are hung on the ends of the lift beam and engaged with the link positioning cylinders. The lift links may be shifted in or out with the positioning cylinders as required to align the lift links with the trunnions on casks of different diameters.

CASK RESTRAINT SYSTEM

The cask restraint system is designed to firmly hold the cask in place to prevent cask swinging during transport. It consists of two (manual) screw operated levers, two hydraulic cylinders with hooks, and a lightweight polyester roundsling located on the lower deck of the Cask Transporter. The cask restraint system is installed after the cask has been lifted and prior to transport. The levers are extended out to the cask's cylindrical exterior, and the roundsling positioned around the cask. Each end of the roundsling is connected to the hydraulic cylinders and when tightened, securely holds the cask in place for transport. Surface damage to the cask exterior is prevented by the use of a fabric type sling, and a thick silicone rubber pad secured to the surface of the screw operated levers.

BRAKE SYSTEM

The Cask Transporter has a combination service and emergency/parking brake system. This consists of a hydraulic caliper and brake disc mounted on each of the six wheel assemblies. The brake calipers are actuated by an air/hydraulic master cylinder. Each wheel pair (front, middle, and rear) has a separate master cylinder. Each master cylinder has a dual function air chamber consisting of an air applied service chamber and a spring applied, air release emergency/parking chamber.

Both the service brake and emergency/parking brake systems are controlled from the tow vehicle via air hoses equipped with a standard gladhand connector. The service brakes are operated from the foot brake pedal of the tow vehicle, supplying variable air pressure as required. A minimum of 620 kPa air pressure at full braking pressure is required for the service brakes. The emergency/parking brake is a spring applied brake requiring constant air pressure to

release and hold released. A minimum of 552 kPa air pressure is required from the tow vehicle to release emergency/parking brakes.

The capacity of the braking system was designed utilizing selected requirements of ANSI B30.2.0 SAFETY STANDARD FOR OVERHEAD AND GANTRY CRANES as a guide. The service brake system is designed to stop a fully loaded Cask Transporter (179.7 Mg, traveling at 8 kms/hr) in 13.4 meters. In the event of air loss, the spring applied emergency brakes are capable of stopping the same fully loaded transporter within 16.1 meters.

CONTROL SYSTEM

An electrical control panel is located at the rear of the open Cask Transporter deck in full view of cask lifting operations. The following systems are controlled from the panel:

- Hydraulic power supply
- Cask lift system
- Cask restraint system
- Lift link positioning

The control panel also includes an emergency stop which will bring all systems to a fail safe position.

HYDRAULIC POWER SUPPLY

The Cask Transporter is supplied with a skid mounted hydraulic power supply system operated from the control panel. It consists of an electrically powered pump with reservoir, pressure regulator, thermometer, reservoir heater, valving, piping, fittings and hoses. This hydraulic pumping unit is used to power the cask lifting system, operate the cask restraint system, and operate the link positioning cylinders. Hydraulic system maximum operating pressure is 20.68 MPa.

All hydraulic power supply functions are controlled from the control panel located at the right rear of the Cask Transporter, in full view of the cask loading area. For convenience of monitoring, a system output pressure gauge is mounted at both the operator control panel and the hydraulic skid.

OPERATIONAL FEATURES

Operation of the Cask Transporter allows for the quick, efficient transfer of the storage cask (see Fig. 3). The operating sequence is as follows:

- Cask Transporter and brake air lines are connected to the site provided tow vehicle.
- Lifting links appropriate to the cask being moved are installed on the lifting beam by site provided crane.
- Cask Transporter positioned to straddle the cask to be moved.
- Parking brakes are set.
- Electrical power is connected, and hydraulic power supply is readied for use.
- Lifting links are engaged to the cask lift trunnions.
- The cask is lifted to clear the ground a minimum of 12.7 cm.
- The restraint system is connected and secured around the cask.
- The electrical power is disconnected.
- Release parking brakes and verify operation of service brakes.
- Tow Cask Transporter and cask to unloading site.
- Unloading is done in reverse order as loading.

The design speed of the Cask Transporter is 8 kph in a loaded condition. To facilitate the transfer of the Cask Trans porter from one facility to another, the unloaded transporter may be towed at up to 24 kph for short trips (16-32 km) on improved surfaces. The speed is reduced to 3.2 kph when loaded and negotiating the minimum turning radius of 9.15 meters.

EQUIPMENT TESTING

The Cask Transporter is thoroughly tested after assembly to verify structural integrity and smooth operation.

Load testing at 125% of it's rated capacity (158.9 Mg) was successfully performed without deformation or failure and demonstrated the following operations:

- Lifting and lowering of the load through full stroke of the hydraulically actuated lift beam.
- Holding of load during simulated hydraulic hose or power failure.
- Holding of load by security bars through lift beam.
- Structural integrity through entire load path.

Load test configuration utilizes a second pair of hydraulic cylinders rigged between the transporter's lift beam and a test frame placed under the Cask Transporter. When actuated, the test cylinders exert the 158.9 Mg test load on the lift beam and entire transporter. By applying hydraulic pressure on the lift cylinders, and operating hydraulic pressure relief valves on the test cylinders, the lift beam is shown to lift the proof load through it's entire stroke. By switching hydraulic pressure to the test cylinders, the load is applied to the lift beam for verification that the counterbalance valve holds the raised load. Additional pressure is applied to the test cylinders until the load

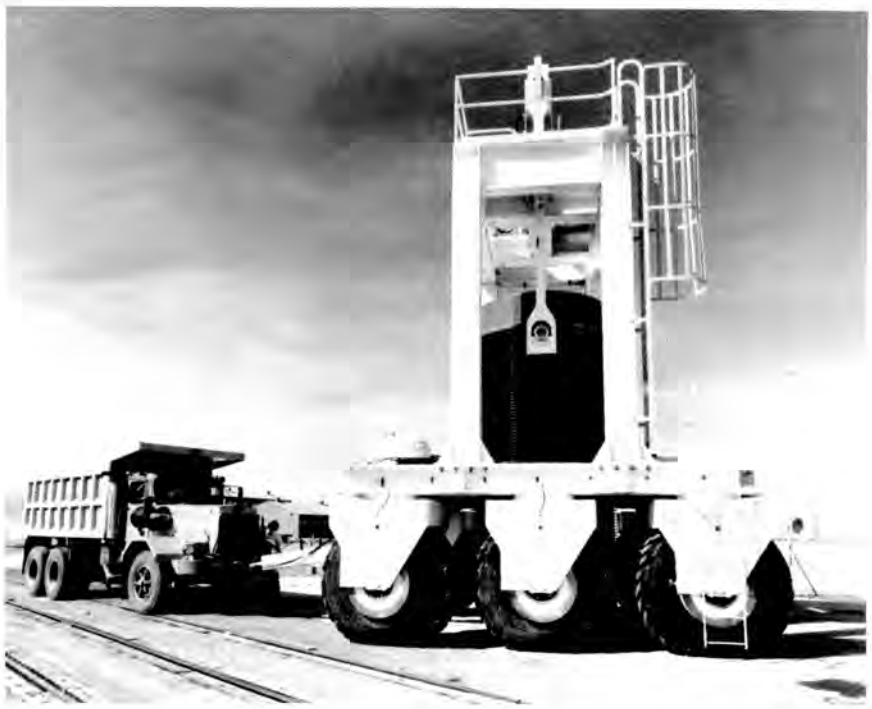

Fig. 3. Loaded Cask Transporter.

holding counterbalance valve is "overridden" and the lift beam is lowered while under load.

No-load operational testing was performed on the following transporter systems to demonstrate smooth operation:

- Emergency and service brakes
- Steering and mobility

Emergency and service brakes were shown to be fully effective in bringing the transporter to a safe stop during normal transport and during loss of brake line air supply. The air applied service brakes and spring applied emergency brakes stopped the unloaded transporter traveling at 8 kph within design requirements. The transporter when accelerating and traveling at 8 kph tracked evenly, without wandering, behind the tow vehicle while being towed straight and around corners.

SUMMARY

The Cask Transporter has met the project needs for an economical and convenient means for moving storage casks within and around the facility. Cask moves have been reduced to a routine event requiring minimal lead time. A single move can be completed in less than 2 hours, requiring 2-3 personnel. The handling and transfer cost savings are more than substantial without the use of large mobile cranes taking several days.