



# **Marine Accident Reconstruction Case Histories - Course 3**

**An Online Continuing Education Course for Engineers**

**Course Number: F-6003**

**Credit: 6 Hours / 6 PDH / 6 CPD**

# CASE STUDY #1

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## *DANGEROUS LAUNDRY ROOM ON A PASSENGER VESSEL*

### *BACKGROUND*

During a very nice seven-day cruise on a large passenger vessel in the Caribbean, a lady passenger decided to use a coin operated laundry room, available aboard the vessel, which was available to the passengers. The washers and dryers were heavy-duty stackable units, with the washers resting on the deck or floor of the laundry room, and the dryers mounted on a steel frame just above the washers. After drying the clothes just washed, the passenger was pulling clothes out of one dryer when the dryer fell on her resulting in serious injuries.

### *DESCRIPTION OF THE LAUNDRY ROOM AND THE WASHER-DRYER INSTALLATION*

The laundry room where the accident took place measures approximately 15 feet in the athwartship direction and 6' – 6" to 7' – 0" in the fore and aft direction.

There are four heavy-duty washing machines and four commercial dryers in this room besides a sink, a permanently mounted folding table opposite dryer #2, two chairs and an ironing board.

Each dryer is mounted on top of a coin collection box about 6" in height (Money Acceptors). The coin collection boxes appear to be an integral part of the dryers and have matching dimensions with the base of the dryers. The dryer/coin box units have an approximate weight of 140 pounds. The dried clothing in the dryer weighed approximately fifteen pounds. Thus, the total weight of the dryer unit involved in this accident was approximately 155 pounds, along with the accumulated weight of coins in the coin collection box.

It appears that the dryers are rigidly connected to the coin collection boxes, therefore, both items reacting as a single unit to any force or vibration applied either to the dryer or to the coin collection box.

Each washer and dryer/coin box pair are mounted on individual steel structures which support both units, with the washer on the lower portion of the structure and the dryer/coin box above it.

The flat floor pads and the square base washer support: The steel structure is welded on top of steel flat floor pads which are welded to the laundry floor towards the athwartship bulkhead, which is to the rear of the steel structure and on the right side of the laundry as one enters the room. Each steel structure has a square base approximately 27" deep x 27" wide x 4" high at the bottom to which the washer is mounted. This square base is welded to the flat floor pads, which in turn are welded to the steel deck.

The steel bases for the washers were not welded directly to the floor apparently because the vessel's steel deck has substantial deformations. The flat floor pads are not as long as the square base they support. The pads terminate 8 ½" short of the front of the square base. Hence, the square base and therefore, the washer that is resting on the square base is cantilever and overhang the flat floor pads.

Because of the irregularities in the floor (which undulates throughout the laundry room), there is an irregular gap between the floor and the bottom of the square bases the washers are mounted on.

The dryer support frame: The square base supporting the washer has two vertical steel channel posts welded to its back corners. These two posts are approximately 35 ¾" high. The posts are the only support for the dryer support frame. The back of the frame is formed by a piece of 1 ¼" x 1 ¼" x ¼" angle iron connecting the two vertical posts. The sides of the frame are formed by two arms approximately 18 1/4" long made of 1 ¼" x 1 ¼" x ¼" angle iron. The arms are connected by a flat piece of steel welded horizontally to the bottom of the two arms. The dryer/coin box unit rests on this support.

Since the dryer/coin box unit measures approximately 27" deep, and the arms are only approximately 18 1/4", approximately 9" of the front part of the dryer/coin box unit is supported.

In other words, the dryer/coin box unit is partially cantilevered off the dryer support frame, and 9" of the dryer coin box hangs over the end of the dryer frame completely unsupported.

The safety tether wires intended to restrain the dryer were not installed: In order to restrain the dryer/coin box from falling forward onto the dryer's user, the manufacturer designed, manufactured and installed safety tether hardware on the dryer's casing. All of the four heavy-duty commercial dryers have factory equipped wire safety tether (approximately 30" long). The wire safety tether is secured to the left and right upper rear corners of each dryer and passed through a stainless steel clip. The clip was intended to be secured by four screws to the athwartship bulkhead of the laundry room located 12" behind the dryers, thereby preventing the dryer from moving or tilting forward. Despite clear instructions in the manufacturer's installation instructions and the clear purpose of the safety tether hardware to any maintenance person, the safety tether hardware was never attached to the bulkhead, as evidenced by the complete lack of holes in the steel walls of the laundry room behind the four dryers.

This hardware was intended to restrain the dryers from sliding or tilting on the dryer support frame towards the front, where the person using the dryer would be standing when loading or unloading the dryer.

During the inspection performed by the author of this case study, it was found that the clips were never secured to the bulkhead and each wire and each clip was hanging loose from the top of each dryer. Hence, unless otherwise restrained, the dryer can slide or tilt towards the person using it due to deformation of the supporting frame, motions of the vessel vibrations created by the washer, and/or the dryer, vibrations created by the machinery of the vessel, or in normal use when the user pulls outwards on the door handle to open the door of the dryer, or pulls clothes from the dryer. If this factory installed safety tether had been properly attached to the wall rather than left unused, the accident would not have occurred as it did.

Bolting dryer to the dryer support frame: Another system intended to hold the dryer/coin collection box units in contact with the dryer support frame consisted of two holes (about ¼ inch in diameter) drilled on the backside of the dryer support frame and two matching holes in the back of the coin collection boxes. These holes purpose was to allow the installation and tightening of two bolts to secure the dryer/coin collection box units to the dryer support frame. During the inspection performed, it was found that bolts were missing and the ones that were visible, were loose or were the wrong size, such as having a bolt 2 ½"

long with a loose nut midway. Obviously, on the day of the accident, there were no bolts securing dryer #2 to its frame, since the dryer was relocated more than 3" when it fell on the lady passenger.

It appears that the only items providing a small force to restrain the dryer from falling completely off the dryer support frame were the electric cables and the dryer exhaust hose. During the inspection it was noted that the sheathing protecting the electric cables of the electric wires for dryer #2 had about 2" of visible separation from its attachment point to the dryer, indicating the dryer had been pulled towards the front with the electric wires being forcibly pulled through the sheathing.

At the time of the inspection, dryer #2 had 2 bolts of different characteristics both completely loose, one 1" long inserted from the outside of the frame and the other 2 1/2" long and less than 3/16" in diameter, inserted from the inside of the frame. These characteristics indicate that it was not an original installation.

The electric panel boxes: Each heavy-duty commercial dryer has an electric panel box installed close behind it on the athwartship bulkhead located approximately 12" behind the dryers. The electric panel boxes behind dryers #1 and #2 cannot be accessed without removing or relocating the dryer, as the support structure is permanently welded to the laundry floor.

It is obvious that from time to time the dryers need to be relocated or removed to access the electric panel box, and, in order to move a dryer, the bolts intended to secure the dryer to their frame had to be removed. The repair or maintenance personnel acted negligently by not replacing missing bolts and by not tightening the bolts.

During the inspection of August 7, 2004, the door of the electric panel box behind dryer unit #1 was closed but in tight contact with the back of the dryer unit #1.

The door of the electric panel box behind dryer unit #2 was open at the time of the inspection because it appears that if the door were closed, dryer #2 would not be able to be pushed back to the back completely onto the dryer support frame, causing dryer #2 to hang out over the end of the dryer support arms even more.

In other words, the electric panel boxes behind dryers #1 and #2 are in the wrong location.

## *DESIGN AND FABRICATION DEFICIENCIES OF THE STEEL STRUCTURE SUPPORTING THE WASHER AND DRYER*

### 1. General

The steel structure supporting the washer and dryer was improperly designed and fabricated because, among other deficiencies, it allows elastic and permanent deformations of the structure towards the front where the user would be located, without positive means of restraining the dryer from falling towards the user.

The center of gravity of the washer and the dryer are not in the center of each unit, but are most probably towards the front of each unit because of the following:

- a). The coin collection device and storage of coins are at the bottom front of the dryer;
- b) When the washer is in operation, the clothes and water in the washer would move the center of gravity towards the front; and
- c). When clothes are being removed from the dryer, the clothes will be pulled and accumulated towards the front.

The above magnifies the effect of having 8 ½” of the entire frame structure cantilevering from the floor pads welded to the deck. Furthermore, the dryer is resting on a dryer support frame that is supported by just two vertical posts originating at the back of the square base frame supporting the washer. Therefore, the entire weight of the dryer, with a center of gravity towards the front, along with the weight of its supporting frame, is creating a cantilever deformation resulting in tilting the frame supporting the dryer towards the front where the user of the machine would be located. In an unloaded condition, the front end of the partial frame supporting the dryer was found during the inspection to be permanently deformed about ½” downwards.

When the dryer is loaded and the clothes are being moved toward the door to remove them from the dryer, it can be expected that the front of the dryer could become 1 ½” to 2” lower than the back of the dryer due to permanent and elastic deformations of the partial dryer support frame, the deflection of the two posts in the back of the partial frame, and the deficient connection of the steel structure to support the washer and dryer previously discussed.

The arms supporting the dryer/coin collection unit were also only attached at one point to the structure. A bracing arm should have been included.

The arms supporting the dryer/coin collection unit should have been the same length as the unit and should have incorporated a piece of angle iron at the front to create a frame into which the unit would rest.

2. Deficiency regarding the elevation of the door of the dryer:

The bottom of the opening through which clothes are placed in the dryer or removed from the dryer should be lower than the height of the eyes of the persons that are expected to use the dryer, in order to allow the user to look inside the dryer for remaining clothes, and to avoid the possibility of the user to attempt to pull herself or himself up using the opening of the dryer as holding structure, to look inside the dryer for remaining clothes.

A survey of several-stacked installation of washer dryers available to the general public, revealed that the bottom of the opening from which clothes are taken had heights above the floor between 50 to 54 inches.

A chart developed by Dr. Steven B. Halls, MD, FRCPC and John Hanson, MSC (see footnote), indicates that 50% of the women, white race of about 65 years of age had an average height of 63 inches. The average distance from the eyes to the top of the head of women is about 5”. Hence, the bottom of the opening from which clothes are removed should be several inches lower than 58”, which indicates that the 50” to 54” found during the survey represents a reasonable “industry standard”.

Footnote: Article entitled: "Women's average height chart, stature gradually declines", can be found at: <http://www.halls.md/chart/women-height-w.htm>.

FRCPC: Fellow of the Royal Colledge of Physeceans and Surgeons of Canada.

During the inspection of the cruise ship, it was found that the bottom of the opening from which clothes are taken was about 61", which is 7" to 11" higher than reasonable industry standards.

Due to deficient design of the base frame supporting the washer, the space between the top of the washer and the underside of the coin collector (2 1/2" to 3") and the thickness of the coin collector (1 1/2" to 2") is 1 1/2" to 2" higher than it would be if the correct design had been applied:

- The base of the washer is 4" high and using a base that is 3 1/2" to 4" high.
- The coin collector is 1 1/2" to 2" thick and the space between the top of the washer and the underside of the coin collector is 1 1/2" to 2" high.

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#### MAIN DESIGN INSTALLATION

In addition, dryer #2 has a panel that is positioned between unit #2 and unit #3 is on the side.

Unit #1 has a panel on the back of the unit on the side.

Because the 12" space on the side of either unit #1 or unit #3, and stretching his arm to reach the location of the dryer #2, and stretching about 36" to reach the location of the dryer #2.

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#### WORK OF

For a pair of units, the panel is positioned between unit #2 and unit #3.

The panel is on the side and on the side of either unit #1 or unit #3, and stretching about 36" to reach the location of the dryer #2.

In view of the above, it can be expected that most maintenance people would not apply the effort necessary to install and tighten bolts to secure dryer #2 to its supporting frame.

The above dangerous condition is the explanation for the absence of the restraining wire and the absence of bolts in the frame securing dryer #2 to the dryer support frame. The absence of bolts probably existed off and on several times since the laundry room was placed in operation.