UNSAFE, DESPITE GOOD ELEVATOR ENGINEERING AND CODES

D. A. Swerrie, P.E. & C.E.I., Safety Consultant, Swerrie, Inc., 244 San Felipe Way, Novato, California 94945, U.S.A.

The mission of our industry is to provide safe vertical transportation. The primary vehicle is the passenger elevator. Our predecessors, understanding that mankind has an ever present, normal and inherent fear of falling, developed safeguards to prevent uncontrolled descent. For one hundred years or more the engineers have emphasized safety and provided one back up safety means after another. The job of safety has been handled so effectively by our industry, that today the word elevator is all but synonymous with the word safe.

In the past, 75%, or more, of company managers, supervisors and engineers had technical expertise, usually developed in the field working on the elevators for which they were responsible. Today, at least in the United States, managers, salespersons, and even engineers and supervisors are increasingly chosen from the ranks of other than field experienced persons. The individual with the degree in business administration is sought. The young person with a degree in electronic engineering is solicited. Equally desirable is the one with selling abilities. There is nothing wrong with such an approach. But often we find that only 25%, or even less, of the staff that design,build and sell elevators have any hands-on experience with them in normal service. Yet, they too have a responsibility for elevator safety.

SAFETY does not start with the code. SAFETY starts with the engineers. SAFETY is subject to the attitude of managers. Maintaining elevators SAFE also depends on the attitude and knowledge of the installing mechanics, the mechanics who service the finished product, and the mechanics who make repairs and alterations to the elevator, Lasting SAFETY is the responsibility of those who regularly, or intermittently, inspect the operational unit. It is from the input of the engineers, the mechanics, and the inspectors that codes are developed. It takes on-going vigilance to provide safe transportation!

SAFETY considerations are rightly an important part of every conference in which elevator engineering, construction, maintenance, or operation is on the agenda. Engineers, managers, and sales persons should seek out field personnel, the mechanics and the inspectors, those persons with hands-on elevator experience, and offer them a place on the agenda. Have them attend the meetings, and hear what is in the planning stages. The engineers should enter into discussions with the field personnel to get their opinions and comments. It is they who know how

things are working out under normal usage. It is they who investigate the accidents and complaints. It is they who most likely will alert the engineer to an unsafe practice or problem, hopefully before the accident.

All engineers know of the device that appeared so effective in the test tower, or on the drawing board, that proved to be a disappointment when put into actual service. Seldom are there tragic occurrences. Sometimes there are! Always, it is the field man, the mechanic, who is first to be alerted that something is not as it should be.

We have done a great job in keeping elevators from falling. But, SAFETY is much more than that! Unsafe conditions can occur at the most unexpected times and from unanticipated sources. The hazard that is the subject of this thesis is fire. Fire and the hydraulic elevator! Fire from an unexpected source and conveyed in an unanticipated way, to be fueled in a totally unforeseen manner. Unanticipated and out of control fire is an unsafe condition. Fire involving an elevator may be even more of a hazard!

The building, a residence building, had three elevators. The elevators were installed in 1972. They were passenger elevators of the hydraulic, direct plunger type. They were well engineered and installed by one of the major manufacturers. Over the years they were maintained and repaired by various, recognized elevator companies using acceptable parts and practices to maintain and repair the equipment. The elevators were typical installations being maintained in a typical manner for the use, and for the area in which they were located.

If 70% of the elevators are hydraulic, then the elevators were about the same as most of the estimated 37,500 hydraulic elevators in California. Not all of them of course, will have the same vulnerability. But sometimes, well meaning mechanics and engineers, can make any one, or more of them, unknowingly and unnecessarily unsafe. Vigilance and communication can help to keep that from happening.

The building was a 7 story residence for the elderly. The top floor was the kitchen, dining and sitting room. The other six were residence floors. On those floors, there was a corridor in the center and apartments on both sides. The elevator lobby was in the center of the building and off of the corridor, slightly recessed so you only saw it when you were there. The entrance to the building was on the first floor opposite the elevators. See Figure 1. The stairs were located at either end of the corridor. The building was not equipped with a fire sprinkler system. There were fire alarm pull boxes, but they were for the building only and were not connected to the Fire Department. There were some battery powered smoke detectors installed in the hallways. The detectors in the elevator lobbies that were connected to the elevator recall system were activated by utility power. There was no basement. Water, due to the high water table in the area tends

to keep pits and basements quite wet. The soil is a serpentine clay that has been formed by the action of the San Francisco Bay over thousands of years. In places the serpentine bay mud is over 150 feet (46 meters) deep. Electrolysis is a serious problem. An unprotected jack can fail in less than a year, sometimes just a few months.

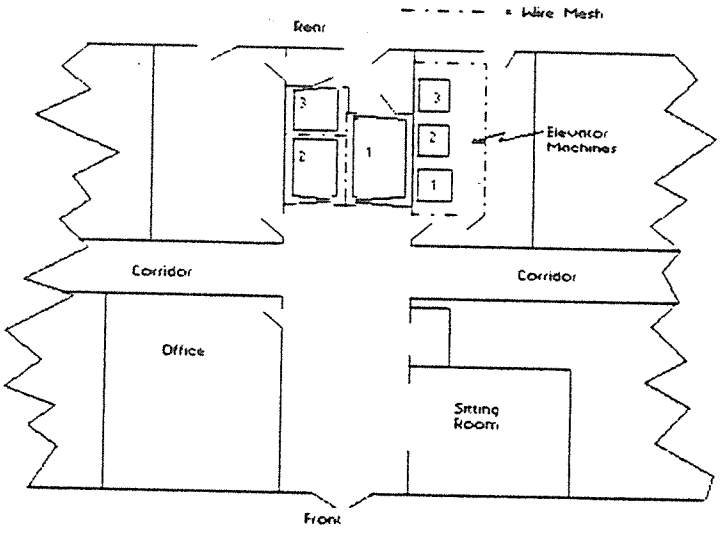

FIGURE 1

Elevators # 1 & # 2 were duplexed and were the elevators used by the tenants and guests. See Figure 1. Elevator # 1 was slightly larger and had a rear entrance on the first floor only. That entrance served the rear, or delivery, entrance to the building. It provided a way to move furniture in and out without crossing the lobby. Elevator # 3 was a service elevator, serving the delivery or rear building entrance and the kitchen on the seventh floor only. Its openings were towards the rear. The elevator machine room was in the electrical distribution room on the first floor. Elevator # 3 and the rear entrance to elevator # 1 were equipped with manually operated swing hoistway doors. All other doors were of the power operated, horizontal sliding type. Elevators # 1 & # 2 were equipped with Fireman's Return and Service.

All elevators were equipped with automatic oil return (scavenger) sump pump systems. The pit was equipped with an automatic sump pump toward the front right corner, in a recess in the pit floor under elevator # 1. The elevator alarm bells were connected to a second bell that was located in the custodian's apartment on the fourth floor. The tenants had been instructed to use the alarm bell intermittently if in need. This was to differentiate the

sound made by news boys or delivery persons holding an elevator. There was no indication of vandalism, mistreatment or abuse of the elevator equipment. The elevators were serviced on a regular basis. They had, in fact, been serviced just 4 days prior to the fire. At that time the pits were cleaned and observed by a witness to be in "quite clean condition".

The evening prior to the fire was a normal quiet time. Most of the tenants retired to their apartments by about 10 p.m. The last use of elevator # 2 was about that time and it was left on the fourth floor. Elevator # 1 may have been left on any floor. Elevator # 3 was secured at the first floor. At midnight a neighbor heard a strange sound coming from the electrical and elevator machine room. He described the noise as rhythmic and repetitious, re-occurring at short intervals. He said it sounded like the noise an electrical switch makes when it snaps in and out, He no longer heard the noise after going to bed at 12:30 a.m. Prior to midnight he was not aware of the noise as he was otherwise occupied. Evidently no one in the building itself heard, or was aware of any unusual noises, except for one person who thought she heard, or felt, an explosion somewhat before the fire.

At about 3 a.m. the custodian was awakened by the loud steady ring of the elevator alarm. He dressed, checked the 4th floor lobby and walked to the first floor. As he reached the first floor the alarm ceased. He then became aware of another sound, a smoke alarm. The smoke alarm was in the lobby where he was going. When he reached the elevators he found elevator # 1 there, its doors open and the entrance engulfed in roaring flames about four feet high. The doors to elevator # 2 were closed, but vibrating from the heat as though "some monster wanted to get out". He automatically reached up and pulled down on the smoke detector, stopping its sound. He unlocked and entered the electrical room where he went into the elevator cage and opened the main line disconnect switches. He then crossed the hall to the office, unlocked the door, entered and used the telephone to report the emergency. The call was logged by the Fire Department at 3:33 a.m. He crossed to the front door and unlocked it just as the police arrived. Within another minute the Fire Department arrived.

The fire had been suppressed and the premises secured by 7 a.m. The first fatality was found a little after 5 a.m, the second a little after 6 a.m. The injured had been taken to the hospital. The remaining occupants had been removed to a local school facility while more permanent lodging was sought. It would be months before the building would be repaired and refurnished. Various incidents that happened during the suppression of the fire and the evacuation of the building make interesting stories. Worth telling when time permits.

The fire itself was confined to the hoistway. The most intense burning appeared to be in the vicinity of the sump recess under elevator # 1. The fact that it was an oil fire was unexpected and

caused the fire suppression crew to change tactics. The fact that the fire was under the elevators further complicated the task of suppression. After the fire was brought under control the suppression crew, anxious to see the area where it had been, cut a portion from the car floor of elevator # 1. The pit was found to contain liquid. A salvage crew was summoned and removed about seven hundred and fifty gallons (2839 liters) of liquid. Samples were sent for analysis. Access to the pit was restricted by two 2" (5 cm) pipes passing directly under, and in the center of the opening in the car floor. The pipes were the oil lines for two of the elevators. On each pipe there was a coupling laying loose i.e. the couplings had no threads to engage the threads on the pipes. By pushing the couplings out of the way the pipes were easily moved to provide access. All other pipe fittings were of the "victaulic" type. It was necessary to cut openings in the mesh enclosures between pits. It then became possible to crawl to all areas under the cars.

A can with its top cut out was found under elevator # 3. The can appeared to serve no purpose and was very similar to an incendiary device. Arson was suspected, with fatalities! The Bomb and Arson squad and the Bureau of Alcohol, Tobacco and Firearms were alerted. Highly trained investigators went into action. Even more restrictive security was imposed.

In a couple of days reports were back, it was not arson! Time and use have demostrated the oil used as the liquid in "hydraulic" elevators is not a fire hazard. Fires with or involving hydraulic elevators are extremely rare. Analysis indicated the oil used here was typical, uncontaminated, and not the cause. What then, extraordinary events or conditions led to this catastrophic fire?

An elevator expert was brought in! Also an electrical expert with fire experience. They, along with the fire cause experts, insurance investigators and the assigned officer from the fire department were to work as a team to determine if possible the cause of the fire. The only instructions were: "work together, help each other, and "let the chips fall where they may", but determine, if possible, what caused the fire!"

Without discussing every theory, every avenue explored, or even attempting to explain the various steps taken, suffice it to say that the investigation was thorough. Control of all evidence was maintained. Many components were sent for analysis. The experts took turns arguing the pro and con of each theory. An elevator company, neither the manufacturer or the service company, was hired to dismantle what was left of the elevators. The experts supervised the piece by piece removal.

The following items, in addition to those stated above, were noted during the course of the investigation.

1. There was about one square foot (.3 m) total hoistway venting for all three elevators.
2. There was an unexplained hole in the rear panel of elevator #

3 measuring about 5"x10" (13x25 cm) about 5'6" (1.7 m) above the floor.

3. The pit sump recess and automatic sump pump had been installed in the last couple of years.
4. There had been excessive leakage and the oil return systems were installed in the past year or two. New packing had also been installed. The frequent additions of oil became unnecessary.
5. The 30HP AC motor for elevator # 2 had burnt out a month before the fire. The motor was replaced with a used motor. At the same time the motor starter switch and overload device was replaced.
6. After the motor, switch and overload were replaced frequent opening of the new overload was experienced if the elevator was left parked at the 4th (or a higher) floor. The service mechanic subsequently re-adjusted the overload, setting it at its maximum rating. (120%)
7. The motor for elevator # 2 was found to be burnt out after the fire. The starter switch contacts were bridged or welded in the closed position. The overload device was found set at its maximum (120%) setting. It was not tripped.
8. The 200 ampere main line fuses for elevator # 2 had not opened. The 200 ampere circuit breaker on the line side of the main disconnect did open.
9. The circuit breaker for the pit lights and outlets had opened.
10. An electrical circuit to illuminate the parking area in the rear of the building had been spliced in at the circuit breaker for the pit service. It did not comply with code.
11. Non-code complying splices of electrical wiring had been made at the new electrical starter switch in the elevator controls.
12. The connections of the motor leads to the wiring from the starter switch had been insulated with plastic tape only. No friction tape had been used. The box containing these connections at the motor had not been closed. Indications of extensive arcing and sparking were found.
13. The return lines for the oil return systems were plastic tubing. The tubing was taped to the steel oil lines.
14. The valves and pumps for both elevators 1 & 2 had been replaced. Each of the three machines had different pumps and valves.
15. Solid state circuitry had been added to the elevators sometime prior to the fire.
16. Smoke markings in the hoistway indicated that elevator # 2 was at the fourth floor for at least some period of time during the fire. When the car descended the leveling switches caught on the leveling cams, and the conduit on the car struck a beam and was dislodged.
17. Guide rails warped.
18. Aluminum fixtures in the hoistway melted and dripped.
19. Copper in a copper pipe and in the traveling cables melted.
20. Copper pellets were found in the burnt out motor indicating the windings had been melting.
21. Copper melts at 1900+ degrees Fahrenheit.
22. Bolsters were bent down on the ends beyond the buffers.
23. Buffer springs had lost their temper and collapsed coil to coil.

24. Spreader beams were forced upwards snapping off the bolts that held them in place.
25. The leveling switches on the car tops had melted or burnt and were gone.
26. Nails in the walls on the 7th floor, fifteen feet (4.5 meters) or more, from the hoistway had been so hot they burnt black marks in the paint through the mud and tape of the drywall construction.
27. Except for the can with the cutout top found in the pit no unexplained devices were found.
28. The oil reservoir tank of the machine for elevator # 3 was all but empty after the fire.
29. Except for some scorched sawdust, and the plastic oil return lines burnt off in the vicinity of the opening in the wall to the hoistway, the fire did no damage in the machine room.
30. A small saw horse found in the pit of elevator # 1 had evidently been there for years and was used as a step when entering or leaving the pit.
31. The packing in the packing glands was found to be burnt hard. It was harder on ram side than on the jack side.
32. The ram could not be moved in the jack on elevator # 2 after the car, bolster and packing were removed.
33. A cheater for the hoistway door interlocks was found hanging on the wall in the electrical room.
34. Analysis indicated that neither the sump pump or the oil return pumps were the cause of ignition.
35. A box with a carpet covering on one side was found between machines # 1 & 2. The box was probably used as a foot stool or step. It was under the vertical portion of the liquid line and plastic tubing at the side of machine # 2 where the oil line came down from the machine tank in preparation of going through the opening in the wall to the hoistway. There was a burn in one corner of the carpet where it was under the vertical run of pipe and tubing.
36. Traces of scorched sawdust were found on the floor between machines 1 & 2. Surface scorching only. The under portion was damp with oil but not burnt.
37. The couplings that were found with no threads were determined to be a type of dielectric or sound isolation coupling wherein the internal portion was a plastic. The plastic effectively eliminated metal to metal contact.

As the facts were made known the course of the investigation would veer. Motor failure in the machine room could account for burning as there was arcing and flashing where the motor leads were connected. The on-going activation of the motor starter for several hours was accepted and the fact that arcing took place to bridge or weld the contacts could be observed. Nothing was found to indicate the travel of flame from either of those two areas to the hoistway and pit. The scorched sawdust and the burn mark in the carpet on the wooden box could not be easily explained. Everything pointed to the fire from the pit trying to get into the machine room. It seemed that there must be another cause of fire in addition to the switch and motor failure.

Then, as the investigation appeared thwarted, a last theory was proposed. One that could account for the conditions found, depend on no unknown facts or coincidental occurrences, and was only dependent on one additional condition, a condition which could be confirmed or nullified by analysis. The scenario was tentatively accepted. Controlled tests were conducted by the county criminal laboratory; the tests were affirmative and the theory became the solution.

Ignition And Fire:

Sometime after 10 p.m. elevator # 2 commenced repetitiously re-leveling at the fourth floor. Probably the packing was leaking. Possibly there was an electrical malfunction. Maybe a combination of both. Sometime before 3 a.m. the motor and starter switch failed. There was violent sparking and arcing at the motor where the wire connections grounded and shorted out. The arcing, which was quite close to the plastic tubing return line for the oil recovery system of elevator # 2, ignited that plastic tubing. The circuit breaker opened. The oil draining from the vertical run of tubing doused that portion of the burn. The horizontal portion separated from the vertical run, sagged somewhat, and burnt the corner of the carpet on the box and continued to burn emitting white smoke along with traces of black smoke. The white smoke was the burning plastic. The black was from burning oil. The tubing, which was flaming, acted as a fuse, burning at an erratic rate of an inch (2.5 cm) every 2 to 5 minutes. The flame was moving toward the hoistway. The tubing sagged further and the traveling flame scorched the sawdust. It would drip burning oil and occasional globs of flaming plastic, but nerver a sufficient amount to ignite the sawdust or start a fire. As the fuse entered the hoistway and traveled across the pit area it was attached to the steel oil lines and in places it probably touched elevator # 3 return tubing, which ignited also. As the flames passed the dielectric (isolating) couplings they may have caused the coupling for elevator # 3 to fail. That elevator, attempting to re-level, would have pumped some 150 gallons (564 liters) of oil into the pit. The dripping flaming plastic and hot burning oil probably ignited the oil residue on the pipes and then the oil that flowed into the pit. At about the same time the oil return system for elevator # 2 functioned to pump oil back to the tank through the oil line that was now a burning fuse. The hot jetting oil acted as a flame thrower spreading flaming oil into the pit. Probably it was a combination of both events that effectively started the fire. Smoke actuated the Fireman's Return and elevator # 1 came to the first floor. This pushed air into the fire intensifying it. The fire caused the coupling for elevator # 2 to fail and the car fell from the fourth floor. This accounts for the "explosion" that was heard. Another 30+ gallons (112 liters) of hot oil was added to the fire. More air from the falling car, acting as a bellows, was forced into the fire. The fire became an inferno. The dielectric coupling for elevator # 1 failed and another 6 gallons (23 liters) of oil was added to the out of control raging fire. The traveling cable burned, wires shorted, the alarm bell sounded.

Summary:

All indications of the flaming fuse that may have been in the machine room, except for the scorched saw dust and the burn on the box, were obliterated by the force of the pit inferno. It tried to penetrate the same hole in the wall through which the tubing and oil pipes passed. The force and heat of that inferno made it appear that all fire moved from the hoistway toward the machine room.

Generally, elevators when installed, comply with applicable codes. With time, changes, alterations and repairs are made, and code violations do occur. Often they are left uncorrected.

The use of "dielectric" or "isolating" couplings in the liquid line was a logical way to reduce noise and/or electrical potential to the jack. It is not against code. Shear problems have also been documented when plastic fittings are used in the oil lines.. Its use should be analyzed, possibly curtailed. If "dielectric" or "isolating" couplings of the type used had not been in the liquid lines, the fire would have been relatively small. The quantity of oil would have been limited to about 3 gallons (11 liters) or less. When engineers are made aware that electrolysis is a problem, they can come up with a solution without causing a hazardous condition. If the problem to be solved is noise, that too can be solved safely.

The addition of an oil return system is good. The use of plastic oil return lines is quite common. It is often supplied with the system purchased. However, it does deteriorate, becoming hard and brittle. It then often breaks necessitating much cleanup. Why use it? If copper or aluminum tubing had been used as oil return lines the fire would not have happened. When the engineers are made aware that plastic tubing will support combustion in air, and that fatalities have occurred because of its use, a recommendation to the code writers that such tubing should be prohibited is in order.

The use and/or addition of solid state controls is an accepted practice. They should be carefully designed and tested. Field repairs and alterations should be discouraged or be checked by the engineering staff.

The replacement of a motor that fails with a used motor is acceptable if the motor is properly rated for the duty. It should be known why the original motor failed. Repairs should be made correcting conditions in need of such.

The installation of a new starter switch and overload is acceptable, but again, know why it is necessary to do so. Know the replacement switches will handle the job. Adjusting an overload device to its maximum should not nullify the protection intended. If the overload had not been set to its maximum the system may have shut down prior to failure without causing a fire.

The fact that the motor lead box cover was not installed is not too unusual. The use of plastic electrical insulating tape without an additional covering of friction tape is common. In this instance, if the junction box had been enclosed the arcing and sparking would have been confined. It would not have ignited the tubing. Friction tape may have provided just the additional protection necessary even without the box enclosure.

Conclusion:

Having recounted what happened, what caused the problem, and having analyzed the measures that would have prevented this catastrophe, can we use this accident to prevent similar incidents? Hopefully it will do more than that.

The narrative was interesting. We can agree that plastic tubing is less desirable than a metal tubing when the hazard is fire. We may even recommend that the code writers consider prohibiting the use of a tubing that will burn. We might agree to do likewise regarding plastic fittings in the oil lines. We can talk about adjusting and testing overloads. The ability to correctly diagnose a problem is also an important consideration.

It is hoped we will go beyond the occurrence discussed. That we will encourage management, engineers, and the sales staff to be alert to what is happening in the field under normal use conditions. That we remember that often the field technician, or even someone with varied background experience may provide that one bit of vital knowledge necessary to solve a problem or avoid an unpleasant incident. That there is much information and knowhow out there if we but ask, patiently listen, analyze and correlate. That it should be documented and be made available to new personnel in the trade so that hopefully, the same oversights will not reoccur. That we try to avoid making the same mistake the second time. Or as the cliche goes, let's not "reinvent the wheel" every time a new group comes aboard.

This thesis has touched on only one occurrence. Field technicians, mechanics and inspectors are aware of others that are happening in normal use. It is quite possible the engineers have yet to hear of them. Management and the engineering staff must know what is happening. With respect for each others abilities, an exchange of information, questions and input from all concerned, field and staff alike, the engineers will be able to provide the answers based on full and adequate knowledge.

With effort we may truly be able to make the word elevator synonymous with the word safe.

SAFE ELEVATORS depend on the willingness of all individuals to share information and work together, as well as unrelenting vigilance.

* * *

D.A. "Dee" Swerrie

Upon being released from the Army of the United States following W.W. II, Mr. Swerrie attended The University Of California at Berkeley, where he received a B.S. degree in Soil Science. He started his working career as an engineer for a company which made soil analyses and recommendations regarding foundations of buildings, towers, tunnels, roadways, and similar structures.

About three years later he went to work for Otis Elevator Company First a helper, and then a mechanic. He worked in construction, modernizations, repairs, as a service mechanic, and finally as a Local Representative for the company.

He then went to work for the State of California as an elevator inspector. Within a few years he was appointed Senior Safety Engineer and was given the responsibility for elevator safety over a region containg some 12000+ elevators. He was later appointed the Principal Safety Engineer and put in charge of the safety program covering Elevators, Amusement Rides, and Ski-lifts for the State of California. He had a staff of some 60 persons working under his direction to ensure code compliance and safety of some 60,000 elevators, 300+ ski-lifts, and a varying amount of amusement rides numbering over 250 at times.

He retired from the State of California and now is president of Swerrie, Inc. He does safety consulting, inspections and investigations.

Mr. Swerrie is a P.E. registered in California.

He is a Certified Elevator Inspector, being certified by both the State of California and the National Association of Elevator Safety Authorities.

He is a member of the ASME/ANSI A17 Elevator Safety Code National Interest Review Committee and the Earthquake Committee.

He has extensive code developing and writing experience with both ASME/ANSI and the State of California.

He teaches at the NAESA Elevator Code School which is for those wanting to sharpen their code knowledge and skills, and for candidates wishing to become certified as elevator inspectors. The NAESA Certification is the only such certification accredited by ASME/ANSI for elevator inspectors that is open to the public.

He also does freelance writing , and has had many articles published in Elevator World.

The Thesis he presents is based on an investigation in which he was recently involved.

* * *