TRANSFORMER FIRE

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On July 24, 1984, a transformer fire occurred at the New York University Medical Center, located at First Avenue and 31st Street in Manhattan. Box 8168 was transmitted for this fire at 0643 hours, a time when traffic related problems are at a minimum. Thus, our companies were able to effect a quick response, arriving on the scene moments after the transmission.

Upon arrival, our units were directed to an open courtyard, housing four belowground transformers, each individually enclosed by concrete walls and vented at the top by a heavy metal grating. The transformers were step-down units (as are most transformers) fed by a Con Edison primary circuit of 13,800 volts, and reduced to produce a 460 volt secondary circuit, which was arranged to supply the Medical Center. The only direct access to the transformers was via openings on top of the grating. The courtyard, approximately 50′ deep by 100′ wide, was enclosed on the north by a one story walk-through passageway, on the south by a fifteen story Health Care Center, on the west by a two story Science Building, and on the east by the School of Medicine, six stories in height. The wings on both the south and east sides had numerous windows and air conditioning units facing the courtyard.

Entering the courtyard via a door in the walk-through passageway, units found the first transformer on the north emitting a white smoke which was venting out of the grating. Since the four transformers had the ability to operate individually and in parallel with each other, power to the Center was never interrupted. With this arrangement, the failing transformers would be automatically cut out of the system, allowing the remaining transformers to supply the necessary power to the complex. Thus, when units arrived, the situation did not appear very serious, when compared to some of the more seemingly critical 10-25 signals that are handled daily.

SAFETY PRECAUTIONS INSTITUTED

Immediately upon his arrival, Battalion Chief Robert L. Cantillo, 8th Batt., requested the response of Con Edison personnel, and then questioned the Center's supervisory maintenance personnel as to the type of oil being used in the transformers. (Note: When notifying Con Edison of a transformer condition, make every effort to get the exact location of the transformer so that they can check their transformer location record book, which will indicate if the transformer contains polychlorinated biphenyls (PCBs).

In addition, the heating, ventilation, and air conditioning system, which had intake louvres facing the courtyard, was ordered shut down to prevent the intake and circulation of smoke-contaminated air throughout the Health Care Center. The Center's maintenance personnel were also requested to shut down the many window air conditioning units located in the six-story School of Medicine building.

While all these safety precautions were being taken, it was determined that the transformers contained a non-contaminated mineral oil coolant. This was confirmed, not only by Medical Center personnel, but also from Con Edison transformer records. Whenever Con Edison records indicate an askeral-filled transformer, it generally indicates that the transformer is contaminated with PCB's at a level of at least 500,000 parts per million. If such is the case, all F.D.N.Y. operations must be carried out in accordance with procedures outlined in FIRE TACTICS AND PROCEDURES, *Hazardous Materials #2*, and *All Units Circular 266*. (For a meaningful understanding of what PCB's are, see *"PCB's: A Closer Look,"* WNYF, 1st Issue, 1983.)

SUDDENLY...AN EXPLOSION

While the members of Ladder Companies 7 and 24 were examining the area surrounding the transformers for extension of fire, overheated conductors, and smoke, the members of Engine Co. 16 stretched a handline, with a fog nozzle, to the first floor doorway of the Health Care Center leading to the courtyard from the south end. At the same time, the members of Engine Co. 21 stretched a second line from the Science Building standpipe system to the doorway of the walk-through passageway at the north end opening to the courtyard. Examination by ladder company personnel revealed no extension beyond the vaults, other than a light smoke condition. Because of the type of occupancy, and the involvement of a transformer, Chief Cantillo used the services of two engine companies and two ladder companies, and held all other units, including Rescue Co. 1, which had responded on the 10-75 signal.

As the transformer continued to emit a white smoke, Chief Cantillo ordered the members of Engine Companies 16 and 21 to maintain their lines at the doorways, and ordered all members from the courtyard. Since the operation seemed to be in a holding frame at this point, it was not considered necessary to keep members in the courtyard pending the arrival of the Con Edison crews. Chief Cantillo's action was also influenced by *Division of Safety Communication #35*, which warns members to beware of seemingly routine situations, particularly those involving manholes and related incidents.

Shortly after all members were clear of the transformer, and without any warning, the white smoke started to turn dark. Then, suddenly, there was an explosion. A huge ball of fire and smoke erupted from the grating, reaching a height of approximately 100′. At the same time, a large amount of oil was spewed into the courtyard. The heat was so intense that the chauffeurs of Engine Co. 16 and Ladder Co. 7 felt its effect on their faces as the heat wave passed out of the courtyard toward First Avenue, where their apparatus had been positioned. These members were approximately 200′ from the courtyard, and were also shielded by the two story Medical Science building forming the west enclosure and fronting on First Avenue. Immediately after the explosion, the members of Engine Companies 16 and 21 activated their lines, playing fog streams on the transformer and the surrounding area, and extinguishing the fire. They also used their lines to provide a water curtain for the many exposed windows. Subsequently, the members of Engine Co. 14 were ordered to stretch a third line with a foam nozzle attached and to stand by, prepared to supply foam in the event the fog lines proved ineffective. Additionally, Engine Co. 1 (Foam Depot Unit) was special-called to transport additional five gallon cans of 3% protein foam concentrate, in the event that the amount of foam on the scene would prove insufficient. Concomitant with these moves, ladder company personnel spread out throughout the complex, examining areas facing the courtyard to make certain that no fire had extended into the buildings via the windows and air conditioning units. Ventilation was also performed where smoke was observed, however, this problem was minimal.

UNDER CONTROL

Because of the intensity of the explosion, it was anticipated that the fire would possibly involve other transformers. It was also feared that a secondary explosion might occur, since on July 23rd (the previous night tour) units of the 9th Battalion operated at a street transformer fire on 40th Street at which, after an initial explosion, a lesser, secondary explosion occurred soon after units had arrived on the scene. This expectancy, however, never materialized. In fact, shortly after the explosion at this incident, the fire was completely extinguished by members of Engine Companies 16 and 21, leaving only a hot transformer generating a white, steam-type smoke.

To cool down the transformer, Engine Co. 16 personnel secured their line to a substantial post and played an unmanned fog stream on the transformer. The members of Engine Co. 21 were also ordered to apply an unmanned fog stream on the transformer to expedite the cooling process. As it became evident that the fog streams were performing their job, there was no need to consider the use of foam.

Not long after, with the situation under control, the fog lines were shut down and Con Edison members were able to approach the vault for their examination. Investigation revealed that both the primary and secondary feeders were completely burnt out, and that the top of the transformer had sustained a split in its casing that was approximately 12″ long. The actual splitting, or breakdown, of a transformer is a rare occurrence according to Con Edison and their engineers, therefore, they will literally perform a "transformer autopsy" in an attempt to determine the cause for the split.

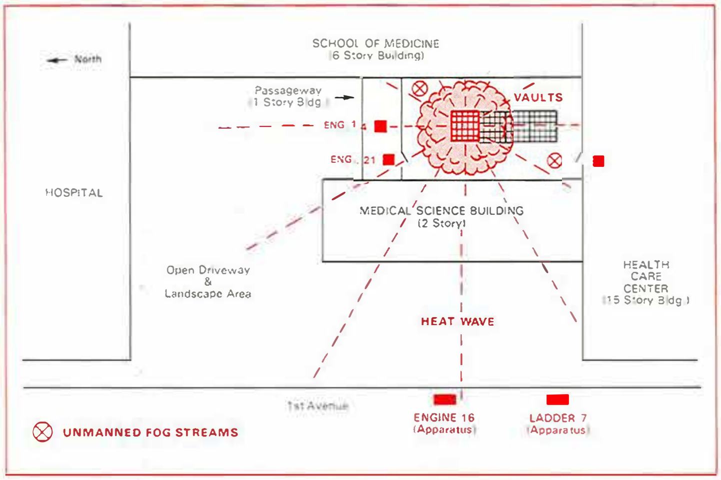

Diagram of fire area and FDNY positions at N.Y.U. transformer fire.

While this operation culminated without undue consequence, it is evident that had our members been close to the transformer when it blew, fatalities or, at the very least, serious injuries would have been sustained by our members. Only the adherence to safety guidelines, established by the Department for hazardous operations, prevented what could have been a major catastrophe. This reinforces the fact that our profession is not a predictable science, and that we must always be prepared to contend with the unexpected.

RECOMMENDATIONS

Thus, it must be emphasized that all operational procedures outlined in *All Units Circulars 180 and 266* are to be complied with. In addition, applicable sections of FIRE TACTICS AND PROCEDURES, *Hazardous Materials* #2 must be considered where hazardous contaminants are known to exist in transformer coolant oils. Above all, it must be realized that since our involvement at the majority of transformer and related incidents is primarily that of examination, removal, notification, surveillance, and security, to operate without planning and control can only produce serious consequences. It is, therefore, recommended that the following points be considered when operating at a transformer incident.

- Full protective clothing and equipment are mandated.
- Always assume oil coolant to be contaminated (unless otherwise informed) and provide maximum protection for all personnel on the scene.
- For maximum safety of both members and the public, treat a transformer incident as if it were a delayed bomb.
- Maintain as much distance as possible between the transformer and the point of operation. Consider the proximity of pedestrians at crowded locations.
- Determine the exact location of the transformer. This information will ensure the positive identification of the oil fill coolant by Con Edison personnel.
- Use unmanned lines when compatible to the incident.
- Prepare, and be ready, for a foam operation even though it may never be activated.
- The use of water on a transformer is not recommended until requested by utility personnel on the scene. The application of water can trigger an explosion.
- Request the assistance of Police Department per-

sonnel to control both vehicular and pedestrian traffic.

WHAT IS A TRANSFORMER?

According to Webster's Collegiate Dictionary (5th Edition), a transformer is *"an apparatus for transforming an electric current from a high to a low potential (step-down transformer) or vice versa (step-up transformer), without changing the current energy; a converter. Usually limited to a stationary apparatus for transforming alternating current."*

In its simplified form, a transformer consists of a core of steel or iron, and two separate coils of wire, with one coil having more turns of wire than the other. The function of the core is to produce a strong magnetic field by means of which the voltage applied to one coil may be recreated in the second coil. A coil alone operating with air as a core is inadequate.

When a coil is placed on a steel core and voltage is applied to it, the core becomes magnetized. This produces magnetic lines of force which are concentrated and channeled by the core into paths of flow which results in a strong magnetic field. When the magnetic field created around the core is passed through a second coil, voltage is produced in the second coil by induction. Thus, if both coils have the same number of turns of wire, the amount of voltage transmitted will be equal to the applied voltage.

Example: If a coil having 250 turns of wire is connected to a 120 volt, alternating current supply, and a second 250 turns of wire coil on the same core is connected to a 120 volt incandescent lamp, the lamp will light up. The lamp is getting energy from the two coils without a direct connection between the coils. The voltage applied to the first coil is being transmitted by induction to the second coil through the magnetized core.

Turns Ratio. The relationship between the number of turns of wire in the two coils is most important and is called the "turns ratio." The effect is that voltage will always be transformed in accordance to the exact ratio between the number of turns of wire in the input coil to that of the turns of wire in the output coil. Thus, if the output coil has fewer turns of wire than the input coil, the voltage transmitted will be reduced in the same ratio as the ratio between the number of turns of wire on the two coils (step-down transformer). And, in like manner, when the output coil has a greater number of turns of wire than the input coil, voltage will be increased at the same number of turns of wire ratio (step-up transformer).

Example: If a 500 turn input coil is connected to a 120 volt, alternating current supply, and a 50 turn output coil is placed on the same core, the difference between input and output will be 500 to 50, or 10 to 1. The output voltage will, therefore, be one tenth of the input voltage, or 12 volts.

In contrast, with an input voltage of 120 volts, and a 1 to 2 turns ratio, the output voltage will be 240 volts. To step-up the voltage, the output coil need only have a greater number of turns of wire than the input coil.

Effect of Turns Ratio on Current Transformation. We have learned that voltage is transformed in exact ratio to the turns ratio. How does turns ratio effect the amount of current that is also transformed at the same time? Current is transformed in the "inverse" ratio. This is, if the turns ratio and voltage transformation are 10 to 1, the current transformation is 1 to 10. If voltage trans formation is 2 to 1, current transformation will be 1 to 2, and so on. Voltage down, amperes up. Voltage up, amperes down.

Example: Turns Ratio 10 to 1

	Input	Output
Voltage	1,000 volts (10 to 1)	100 volts
Current	10 amperes (1 to 10)	100 amperes

Thus, the amount of power given out by a transformer is about equal to the amount of power it receives. This is explained by the equation: "Power in watts equals volts times amperes."

Using the figures in the above example, we see that the input power of the transformer would be 1,000 volts times 10 amperes, or 10,000 watts. We also see that the output power would be 100 volts times 100 amperes, which also equals 10,000 watts. Practically no power loss occurs, making today's transformers about 99% efficient.

The very small fractional losses are due mainly to the inescapeable factor of heat, which is created in the core and coils. Loss is caused in magnetizing the core, and is also lost in the coils by their resistance to the flow of the load current. These losses must be kept to minimum if the core and coils are to operate at maximum efficiency, because the more current there is, the more heat there is. And, excessive heat is damaging to the insulation. The excessive current of an overload will cause the coils to burn out and put the transformer out of service.

The most common method of keeping the temperature of the core and the coils down to within safe operating limits is to immerse them in non-conductive oils. The purpose of the oil is to dissipate heat, and so lower the temperature of the core and coils. The coolant is circulated around the core of the transformer, which picks up heat and it carries it to radiator fins outside of the transformer casing, where they are cooled by air. In the past, askeral liquid was commonly used, since this was a relatively non-flammable oil. However, because this oil contains PCB's, which are considered hazardous to both health and environment, coolant oil containing PCB's can no longer be used in new transformers. (Note: While PCB liquids are banned in new transformers, they will still be found in older installations. Therefore, the identity of the oil in a transformer must be one of the first actions to be taken when operating at transformer incidents.) The other type of liquid cooled transformer is known as the oil-insulated type. This type of transformer uses a flammable, inhibited-mineral, insulating oil. These are the most common, and present the greatest fire hazard owing to the flammability of the oil.

CONCLUSION

Transformers are generally considered the most important single type of equipment in the entire process of distributing electrical power from the generator to the consumer. And, while the information contained in this article on how a transformer works has been described in the simplest of terms, it is hoped that it will be of assistance to those field units that are confronted with transformer fires and other like emergencies. ▲