CTI TECHNICAL BULLETIN
Number 6: A publication of the Cable Tray Institute

Circuit Integrity of Cable Tray Wiring Systems During Natural Disasters

Natural disasters of past years emphasize that the design and installation of structures and systems should be such that the damage is kept to a minimum when a disaster occurs. Even though having been damaged to some degree, it is important that the continuity of service for critical systems be maintained until it is safe to shut the systems down. Figure #l is an Earthquake Seismic Zone Map of the United States. Figure #2 is Wind Velocity Map for the United States.

It is extremely desirable that the circuit integrity of communication, instrumentation, lighting, power and safety circuits be maintained when critical conditions exist. This is especially true for process and utility facilities where there may be the potential for human safety problems, facility safety problems, adjacent facilities safety problems and pollution problems.

To obtain high levels of continuous service, it is necessary that the electrical wiring systems specified have features that will enhance the possibilities of the electrical circuit integrity being maintained under disaster conditions. The wiring systems must be properly designed and installed using quality materials to obtain the desired results. There are design and installation innovations that must be incorporated in the wiring systems.

Wiring System Selection Cable Tray Wiring Systems vs. Conduit Wiring Systems

Due to the materials that make up the systems, the circuit integrity of cable tray wiring systems will often excel that of conduit wiring systems. During an earthquake of significant magnitude, long runs of conduit wiring systems are very likely to be damaged to the extent that their insulated conductors lose their circuit integrity. An EMT conduit system has a very high probability of tearing apart and damaging the conductor insulation producing circuit failures. Rigid aluminum and steel conduits can fracture in the threaded areas at the couplings damaging the conductor insulation producing circuit failures. If the conduits are being used as the equipment grounding conductors, unsafe operating conditions result if the circuits continue operating with the equipment grounding conductor circuit open.

No similar relationships exist between the cable tray and the tray cable compared to that between the conduit and its insulated conductors. The failure of the cable tray does not produce a conductor insulation failure in the cable which results in the loss of circuit integrity.

A Design and Installation Philosophy

Above ground pipelines in some earthquake prone areas are designed so that if they leave their support systems they will not fracture but will go safely to the ground. In these cases the pipelines are usually on supports that are just a few feet off the ground. In the appropriate locations, this philosophy can also be applied to cable tray wiring systems.

The “Fall to the Ground and Continue to Operate Feature” is much easier to obtain for cable tray wiring systems than for pipelines. Cable Trays wiring systems can be designed and installed so that under severe earthquake conditions the tray cables will fall to the ground with a very good probability that there will not be a loss of circuit integrity. This may be important where the cable tray contains critical circuits related to the control and safety of pipelines, tank farms, loading docks, facility utilities, critical industrial process, waste treatment plants, water preparation plants and in some commercial facilities.

The design and installation philosophy described here may not be acceptable or desirable for many installations. For those installations, Seismic Restrained Cable Tray Wiring Systems may be obtained by providing the proper multidirectional bracing for the cable tray supports.

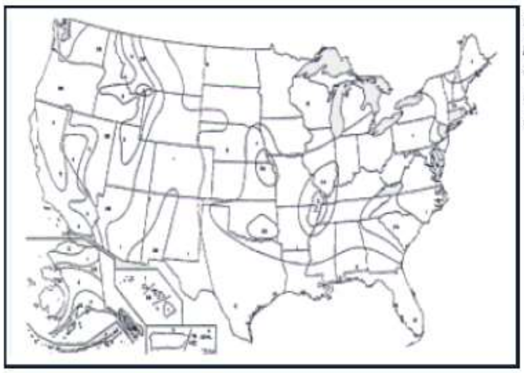

Fig. 1 The 0 to 4 values show the relative earthquake potential magnitude areas. These values are related to the seismic zone factors that are used for earthquake design requirements. For additional information see the "Uniform Building Code."

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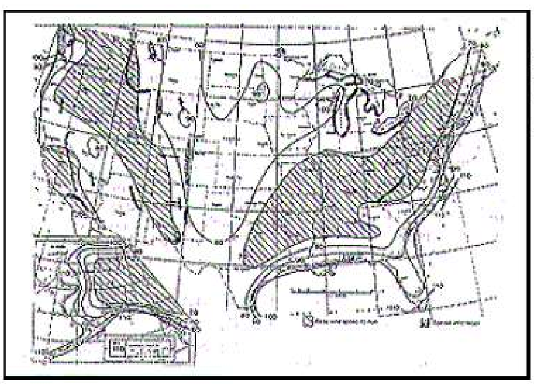

Fig. 2 Potential wind speeds (miles per hour). Values are fastest speeds 33 feet above ground level. For additional informatin see the "Uniform Building Code" or the "National Electrical Safety Code."

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Some prudent design and installation decisions can be made to minimize the damage to cable tray wiring systems due to earthquake or very high wind conditions. Use quality heavy duty cable tray such as a NEMA Class 20C designation (Good for 100 pounds/foot where the distance between supports is 20 feet or less). Properly design and install the cable tray runs. Use quality cables, the cable selection is very important. The cable’s construction, jacket material and conductor insulation should be those that will best serve the requirements of the installation. This is not an area for the cheapest cable that it is possible to obtain. For these installations, listed cables should be used. For circuit safety, the individual cables should contain an equipment grounding conductor.

Design Features

In the event that a cable tray or the cable tray support system in a long cable tray run fails during an earthquake or hurricane, surplus cable length (cable slack) in the cable tray will be a very important factor. The surplus cable length will allow the cables to fall to a lower support level or all the way to the ground. The cable will have a high probability of continuing to function. The height of the cable tray run above a potential support level for the cables is an important factor. For the cable tray runs that are high above a support level for the cables, it may be desirable to make special provisions to insure that there is surplus cable length in the cable tray. This is easily provided for the small diameter cables that have small bending radii by increasing the width of the cable tray at certain increments in a cable tray run (See Figure #3). The placement of these increased widths and their lengths would depend on the layout of the cable tray system. One should be within 100 feet of the control room building or the motor control center building. If the cable tray system goes down, there is enough surplus length in the cable near the buildings so that no excessive force is exerted on the building wall or on the cable terminations. The other positions for surplus cable positions might be required every 300 to 500 feet. Each long cable run should be analyzed to make sure that such installations are absolutely required. This is not something that should be overdone. For installations that are just a few feet above the ground and the cables have not been pulled so tight that some cable slack exists, special provisions to add cable length are not usually required. The configuration of the cable tray system is important. A system of many bends will usually have sufficient cable slack so that provisions for surplus cable length are not required. It is necessary that the designers do a little “what if logical analysis” of the cable tray systems.

For the feeder and branch circuit power cables that have bending radii that can’t be accommodated in the configuration as shown in Figure #3, there are other solutions. A wider cable tray may be used for the full cable tray run. The cables can be installed in a gentle sine wave configuration over the length of the cable tray run. There are innovative ways to obtain surplus cable length in the cable tray run for the large diameter cables by having an “S” loop in the large cables as they drop from one cable tray to another at a different level.

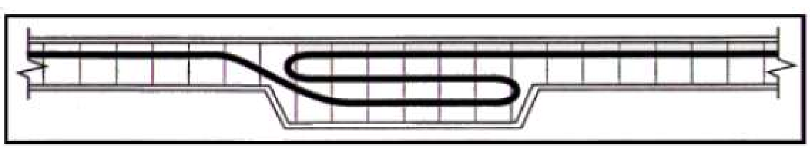

Fig. 3 Installation practice to provide surplus cable length (cable slack) for small diameter cables in a cable tray run. Installation shows ladder type cable trays with reducers between the different widths of cable tray. Bending radii of the cable must not violate the cable manufacturer's recommendations.

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Cable Tray Wiring System Dependability is Based on 30 Plus Years of Operating Experience

Why does the author feel that the proper type of tray cables used in cable tray wiring systems can maintain circuit integrity in earthquake and hurricane situations? My many years of actual experience with cable tray wiring systems have provided me some very good information. Cable trays and the tray cable can be subjected to sever abuse and still safely perform their functions in a dependable manner.

Impact Tests

In 1973 at the Decatur, Alabama Plant of the Monsanto Company, members of the National Electrical Code's Cable Tray Technical Committee had a two day meeting. This was to work on the revision of Article 318- Cable Tray for the 1975 NEC. The members of the committee wanted to study large industrial installations of cable tray wiring systems. A test set up was made of a cable tray section that contained several types of multiconductor power and instrumentation tray cable. This set up was mounted on supports three feet above the surface of the ground. Several members of the committee had the opportunity hit the cables in the cable tray with 8 pound sledge hammers. After a number of hits, the cable tray was damaged but the damage to the cables was cosmetic. Inspection showed that the electrical integrity of the insulated conductors in the cables was not lost by the impact of the sledge hammers on the cables.

A real life industrial cable tray wiring system would not have its cables subjected to this degree of physical abuse. The quality tray cables of today have much better impact resistant characteristics than those of the early 1970s. Tray cables have the ability to take a great deal of abuse and keep on functioning without problems.

Hurricane Experience with Cable Tray Wiring Systems

The high winds that accompanied one hurricane gave us some evidence of the impact of strong winds on a cable tray wiring system. In the late 1980s, several electrical engineers in my organization were in involved in the startup of a new chemical plant unit at a Texas Gulf coast site. One of the feed stocks for this plant was Hydrogen Cyanide. The engineers had incorporated the most desirable monitoring and safety systems in the plant design. During the startup period, a hurricane in the gulf produced some 80 mile per hour wind bursts at the plant site. One run of cable tray, in an exposed position 30 feet above the ground, that contained a light weight cable load, had not been properly clamped properly to its supports. The cable tray went down and some of the tray cables dropped to the ground. Some of the cables hung drooping from the support steel. The control room and the motor control room wall cable transits were compression type so they had very strong grips on the cable jackets. No force was transmitted to the conductor terminations as a result of the cable losing their support or as a result of the wind action on the cables. Not a single instrumentation circuit, computer circuit, control circuit or branch circuit lost its integrity. All circuits continued to function. In due time the cable tray was replaced and properly clamped down. No electrical circuit outages occurred during the storm after the wind storm or while the cable tray was being replaced. The cables damaged were cosmetic. None of the cables required replacement. This event showed that quality tray cables could withstand some harsh conditions with no problems. These cables all contained their own equipment grounding conductor.