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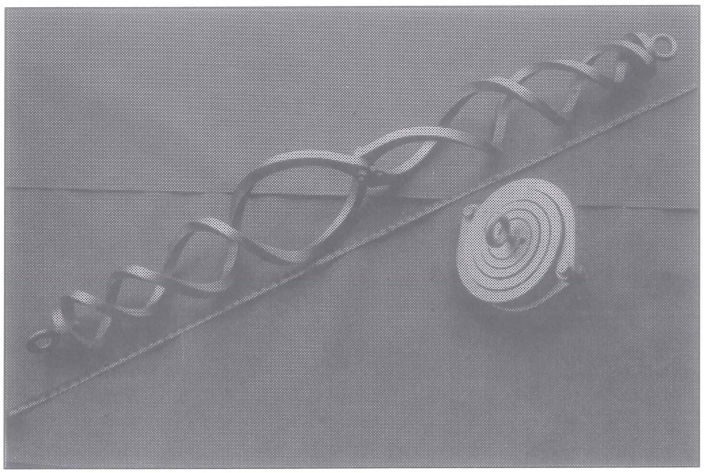
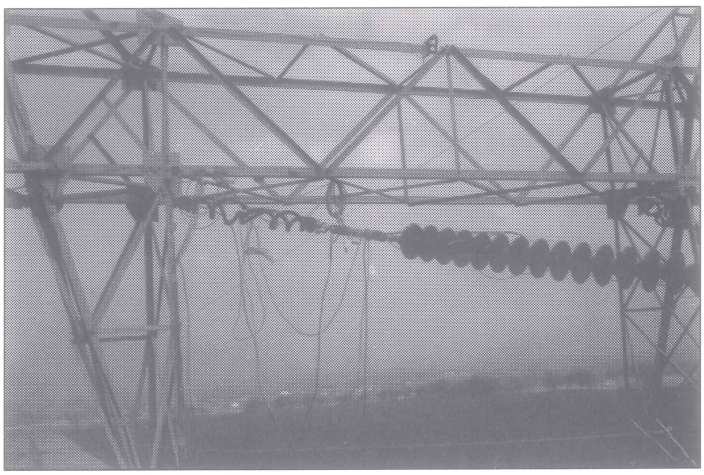


The TL3 in the unextended and extended positions.



An extended TL3 protects a 345 kV tower from damage.

ANCO Develops Transmission Tower Load Limiter

DUCTILITY FOR BRITTLE TRANSMISSION TOWERS

Many electric power transmission towers are designed with a relatively brittle lattice steel structure that is prone to failure when subjected to extraordinary single dynamic events caused by storms, wind, tree strike, ice load shedding, tornadoes, aircraft impact, stringing accidents, and vandalism. "Brittle is an odd way to describe a mild steel tower," explained Dr. Paul Ibanez of ANCO, "but this term refers to the transmission system as a whole, because tower systems are often designed to rely on tension of the power line to provide lateral and torsional stability. When this is lost, or extraordinary peak loads are experienced, the tower has only a few inches of ductility before catastrophic failure occurs. Several feet of ductility are needed to prevent tower failure." In the worst scenarios, miles of towers have been lost in a domino effect emanating from a single event.

ANCO DEVELOPS A LOAD LIMITER

Working with the **Bonneville Power Administration** and the **Department of Energy** (under the SBIR Program), ANCO has developed and performed full-scale tests on a Transmission Line Load Limiter (**TL3**) to provide existing and future tower designs with much needed ductility. The TL3, shown above, consists of a double flat dual helix that is placed between the tower and the insulator string. The TL3 is constructed from galvanized flame cut carbon steel and is designed to meet the following criteria: **simple and rugged** design necessary for line hardware, **compact** construction to avoid affecting tower design on retrofit, and very **cost efficient** to manufacture.

In a typical configuration, the TL3 weighs 40 kilograms (88 pounds) and is 15 centimeters (6 inches) long. The TL3 behaves as a rigid link under normal loads. In the event of a dynamic load that could fail the tower or tower arm, the TL3 extends plastically up to 2 meters (7 feet) to absorb the shock energy and limit the force applied to the tower or adjacent towers. The properties of the device can easily be adjusted by varying the thickness and material of the plates, width of the helix, and the preset force. The TL3 can also be locked out with a simple bolt to facilitate installation and tower servicing without activating the device.

PROOF TESTING AT THE EPRI TLMRF

Working with the **Electric Power Research Institute** tower test line at its Transmission Line Mechanical Research Facility (**TLMRF**) near Fort Worth, Texas, ANCO tested the TL3 on typical 345 kV towers with five Single Bluebird conductors and 305 meter (1,016 feet) spans. Broken conductor tests were made on the center and end spans of a nine tower line, with and without TL3 units installed (see photograph above). Without the TL3, the peak conductor force experienced was **150%** of the insulator string dead weight load, sufficient to cause **significant damage** (though not collapse) to two towers. With the TL3 in place, the peak force was **reduced to 50%** of this value and **no damage occurred**; demonstrating the usefulness of the TL3 in providing significant additional margin to transmission lines experiencing failures.

COMMERCIALIZATION SOUGHT

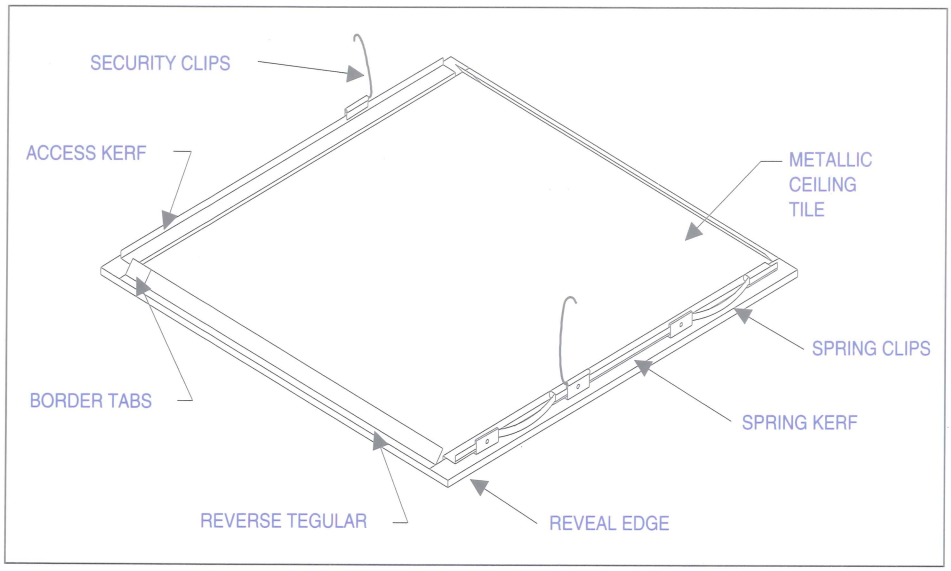
Dr. Ibanez, the co-inventor of the TL3, indicated that ANCO has received a patent on the transmission line load limiter and is seeking to work with EPRI, line hardware manufacturers, and electric utilities to commercialize the device. He added that, "the ability to absorb energy adds a significant advantage to slip clamps, shear bolts, breakaway arms, and other approaches proposed in the past. In addition, the installation of the device to existing structures appears to be a **more positive** and **less costly approach** than replacing or reinforcing the structures."

ANCO *Engineers, Inc.*
Culver City, CA **(800) 932-5515**

New Suspended Ceiling Design Seismically Tested

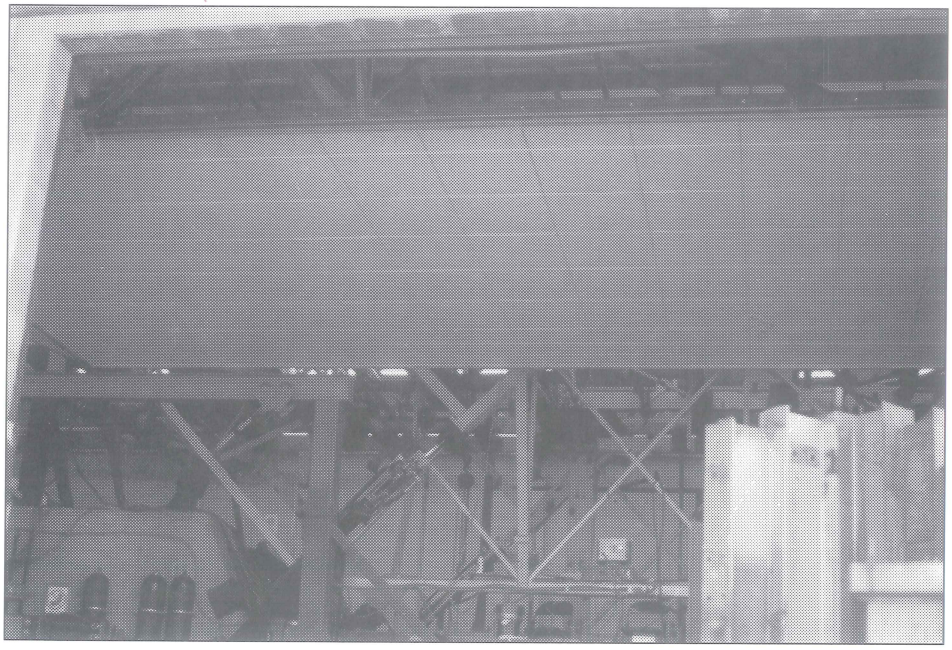
SEISMIC ASSURANCES

The seismic ruggedness of an innovative new design of an Armstrong suspended ceiling was demonstrated by shake table testing. The test ceiling and an individual ceiling panel are illustrated below. Mr. Jay George, Principal Engineer with Armstrong World Industries Research and Innovative Division in Lancaster, Pennsylvania, indicated that "before we could place this new product on the market, we had to assure ourselves of its capability of withstanding the earthquake environment of the Western United States." The ceiling product is easily installed onto 15/16" T-bar grid and is downwardly accessible. The panels were designed for use primarily in corridors and lobbys; however, the design allows for the use of metallic ceiling tiles, which are ideal for critical facilities requiring cleanliness, such as food and pharmaceutical processing, semi-conductor manufacturing and medical treatment areas.



Above: *Drawing showing components of the innovative new Armstrong ceiling tile.*

Below: *A photograph of the test ceiling installed in ANCO's seismic test laboratory.*



UBC REQUIREMENTS MET

ANCO proposed a test program to document the seismic performance of the new ceiling system during simulated earthquake motions which may occur in Seismic Zones 2A, 3, and 4 as defined by 1988 and later versions of the Uniform Building Code (UBC). Towards that end, a 14 by 24 foot ceiling was installed to UBC requirements on ANCO's R-4 overhead shake table. A 30-second earthquake time history was developed which represented the expected motions of the third and sixth floors of a six-story moment-resistant steel frame structure located on a soft soil site. This mid-rise structure was chosen since significant structural amplification of ground motion would occur within the amplified region of the UBC design response spectrum. Test amplitudes were then scaled up or down so that response spectra computed from measured test input motions enveloped the in-structure floor response spectra for Zones 2A, 3, and 4 for non-structural components supported within critical facilities.

CEILING EXCEEDS ZONE 4

The ceiling performed well up to and beyond the high seismic requirements of the Western United States (Zone 4). Minor damage occurred at higher levels when the shake table was commanded to displace more than its displacement limits would permit, resulting in multi-g impact loads. Had severe impacting not occurred, the entire ceiling system would have survived the most demanding tests without any evidence of seismic exposure. Seismic ruggedness of the ceiling system, under normal Zone 4 excitation, was clearly demonstrated.

OVER 10 YEARS EXPERIENCE

ANCO has been involved in testing ceiling components since 1981 and, in addition to Armstrong, has worked with the National Science Foundation (NSF), Ceilings and Interiors Contractors Association (CISCA), Chicago Metallic Corp., and other ceiling component manufacturers to improve the seismic performance of their products and to evaluate the efficacy of a variety of proposed code changes.

For more information, contact Steve Keowen, Los Angeles

ANCO Engineers, Inc., (800) 932-5515

Los Angeles:
9937 Jefferson Blvd., Suite 200
Culver City, CA 90232-3591
Tel: (310) 204-5050
(800) 932-5515
Fax: (310) 202-6085

Denver:
200 Union Blvd., Suite 430-0155
Denver, CO 80228
Tel: (303) 575-1358
(800) 932-5515

East Lansing:
2105 University Park Dr., Suite A
Okemos, MI 48864
Tel: (517) 349-8223
Fax:(517) 349-8253

New York:
244 Madison Ave., Suite 380
New York, NY 10016
Tel: (201) 361-5291
(800) 966-8451
Fax: (800) 622-5375