PRESENTATION

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Although Mr. Young closely followed material from the synopsis, he explored other topics as well. The material below has been summarized from Young's notes and the transcript of the proceedings. The material has been reviewed by the presenter for accuracy.

Young first defined *management* as "the art of judicious use of means to accomplish an end" (as opposed to *mitigation*, which is the act of making something less harsh or less painful). He then discussed both electric- and magnetic-field management (the synopsis focused more on magnetic-field management).

Early EPRI research on management of electric fields focused on several areas, all associated with transmission lines: the magnitude of voltages induced on ungrounded objects near high-voltage lines; the discharge current magnitudes that might be expected from large vehicles parked under such lines; the probability of igniting fuel when refueling under a transmission or distribution line; danger tree or wood-pole burning; and mini-shocks for personnel working on an energized line. In some cases (such as concern over touching large vehicles parked under lines), the current flow was found to be well below the let-go current threshold level (i.e., no hazard). Shielding or other mitigative actions proved relatively easy to accomplish for electric fields. However, results such as underslung shield wires can be unsightly. The results from all these studies are found in the Red Book (EPRI Transmission Line Reference Book for 345-kV Lines and Above).

In his discussion of magnetic fields—which presented a much more complex problem—he noted that researchers focused on ways to reduce the magnitude of the field. This action would affect TWA exposures (although it was not yet clear what the "goal" field level was). A decision was made not to look for a single method of reducing fields, but to develop a large number of options, so that utilities could choose the most effective method to resolve a specific problem. Young also noted that no research has yet been done to develop techniques to deal with transient fields, or with changing the direction or polarity of the field, in part because these would require entirely different techniques.

Initial efforts focused on transmission lines and the attempt to discover what configuration produced the lowest field. Efforts included reverse phasing and compacting, as well as other designs discussed in the synopsis. He stressed the importance of recognizing that, although there are numerous options for reducing 60-Hz magnetic-field levels, careful engineering analysis must be carried out before applying any of the options, in order to ensure that other undesirable characteristics are not increased. Such analysis also can point to cost-effective options: special configurations might need to be done only for a few critical spans, not a whole line.

Young expressed the opinion that more people would be exposed to fields from distribution lines than from transmission lines. This is based on the large number of people near distribution lines compared to transmission lines. He discussed the problem (also covered in the synopsis) of ground return currents. A study at the EPRI facility in Lenox, MA successfully tested variations to the grounding system. However, he cautioned against presuming that changes in the grounding system to address EMF were without consequence: grounding patterns over many years have been developed with an eye to meeting certain safety needs. Simply "uncoupling" the house from the ground system is dangerous. Young also addressed the complexities of having feeders from two different substations serving the same area with grounding paths provided by common water pipe system in this case: eliminating current flow from one source may not successfully address the net-current problem.

Under EPRI sponsorship, a net-current control device (technically a common mode choke) has been developed and tested on the Rochester Gas and Electric System (patent held by EPRI). Commercialization of this device is the key to success and to reduction of cost to a tolerable level.

Another way to reduce fields is to put lines underground, but it is a very expensive alternative and actually can produce a higher field for those immediately above the cable (3 feet away) than for those under wires suspended 40 feet above the ground. The split phasing, shielding, and other options available for overhead can also be applied to underground lines. One may also place a line in a metallic sheath (pipe-type cable) to significantly reduce field at the surface of the ground.

Some limited work has been done on fields in substations. The highest sources of fields are lines coming in and out of the substation; other equipment can be placed in the middle of the substation (away from the fence).

Young also discussed shielding and shielding materials (e.g., steel, copper and aluminum). Composite shields can also be constructed, say, from steel and copper, but joining the different materials at the edge is critical in order not to interrupt the magnetic or electrical circuit.

In discussing RAPID Project #8 (see enhanced Executive Summary in Appendix B), Young noted that the Project had identified several problems where field management would be difficult to address: lines at 500 kV and above; net current associated with distribution lines; transformer and switch gears inside buildings; industrial welding and metal melting processes; and electric railway systems. He also summarized several conclusions from the project: that fields from unbalanced currents on transmission lines might be mitigated by low-impedance ground wires; that the shielding of underground distribution circuits may be necessary; that residential grounding practices have a large effect on field levels in home but must be dealt with carefully; and that electric-train transportation poses considerable challenges to management fields.

SUMMARY OF DISCUSSION

Several issues were discussed following the presentation on field-management technologies by Dr. Frank Young. The summary below was prepared from the symposium transcript.

Discussants raised several questions about the net-current control devices that Young had described in his presentation. He indicated that they had looked at safety and other problems that might arise if the neutral conductor were broken, but found no problems. If the neutral conductor breaks, the neutral current choke coil in the device saturates and a buzzer sounds in the device. The customer would hear the buzz and call the utility. Young did not recall the amount of voltage rise associated with the broken neutral condition. Young was also asked whether installation of a large number of the devices in a neighborhood would compromise the integrity and reliability of the distribution system. He responded that a study modeling widespread application of the devices had not found any problems related to reliability or safety. However, they have tested only individual net-current control devices in the field.

Several discussants re-emphasized a point that Young had made repeatedly in his presentation: modifying the electrical system to manage electric and magnetic fields must be done in the context of safety, reliability, maintenance, cost, and the other environmental constraints. Young and others pointed out the need to perform a complete engineering assessment and design when implementing any field-management strategies. One discussant emphasized the particular importance of this step when considering changes to residential grounding systems, which are designed and installed to prevent electrical shocks and fire hazards. Another discussant described how possible field-management options would be evaluated in designing a transmission line.

A discussant asked whether an engineering study had been done on electrified railways: how effective might simple changes to the power supply (such as adding a second conductor) be in reducing magnetic fields in passenger compartments? Dietrich responded that various approaches had been tried that might reduce fields. These include unsuccessful attempts with multi-conductor pickups that would allow the use of AC instead of DC power. To confirm the elevated levels found in electrified rail cars, a discussant reported measurements of 300- to 1000-mG fields above the motors in passenger compartments of regional railways in the mid-Atlantic region.

In order successfully to interrupt the ground return path through the water system, one discussant suggested insertion of an insulating connector ten feet beyond the building. Another discussant responded, agreeing that installation of an insulated coupling is acceptable in the electric code as long as there is 10 feet of metallic water pipe; however, he strongly emphasized that there is a fire hazard if the resistance of the ground provided by the pipe exceeds 25 ohms and the neutral connection is broken. Therefore, he cautioned against inserting an insulating coupling without a complete knowledge of grounding practices and monitoring of the status of the grounds.

Submitted written comments on this topic are found in Appendix C.

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