Exhibit 3

Affidavit of Mary Byrne

EB-2011-0120

IN THE MATTER OF the *Ontario Energy Board Act, 1998*, S.O. 1998, c. 15, (Schedule B);

AND IN THE MATTER OF an Application by the **Canadian Distributed Antenna Systems Coalition** for certain orders under the *Ontario Energy Board Act*, 1998.

AFFIDAVIT OF Mary Byrne

(sworn September 1, 2011)

I, Mary Byrne, in the City of Pickering, Province of Ontario, **MAKE OATH AND SAY**:

1. I am the Manager, Standards & Policy Planning of Toronto Hydro-Electric System Limited ("THESL"), and up until June, 2011, one of the responsibilities of my department was to process the requests for pole attachments and duct leasing. Other functions of my department include creating and maintaining certain THESL standards, ensuring compliance to Electrical Safety Authority ("ESA") regulations, overseeing the Conditions of Service, and coordinating capital work with other utilities in the City of Toronto. I therefore have knowledge of the matters to which I depose in this affidavit, unless stated to be on information and belief, in which case I state the source of my information and believe it to be true.

A. <u>THESL's Distribution Poles in Context</u>

2. As I explain in further detail below, THESL's distribution system is composed of an extensive and complex network of distribution poles and, as a result of constant pressure to adapt to changing demands, that distribution system is not static. Accordingly, designing, constructing and maintaining THESL's distribution system and the network of distribution poles within that system, is a complex, technical and costly process that is held in a fine balance.

i. THESL's Distribution Poles

3. THESL constructs, operates, and maintains an extensive network of primary distribution poles, principally for the purpose of suspending its primary voltage electrical distribution equipment safely above public thoroughfares. Currently, THESL owns approximately 140,000 distribution poles, located across its entire service area ("THESL Pole(s)"). THESL also

anticipates the transfer, in 2012, of approximately 40,000 secondary poles from its streetlighting affiliate to THESL. These secondary poles suspend streetlights and secondary voltage distribution conductors.

4. Electricity distribution assets are long-life assets. As THESL's current distribution system was inherited from the six former municipal electric distribution utilities that existed prior to the amalgamation of the City of Toronto, portions of THESL's distribution system are considered "legacy" assets. Each former municipal electric distribution utility each had their own individual standard distribution pole arrangements, configured distribution equipment differently on their respective poles at different points in time (e.g. choice of voltage or circuit configuration to serve customers in a given area), and undertook infrastructure expansion and replacement at difference paces. Accordingly, the configuration, condition and congestion of THESL Poles today is highly varied.

5. Included in the collection of THESL Pole infrastructure are cedar poles, concrete poles of various classes, and steel poles. The pole framing standards include various arrangements and configurations of conductors (such as vertical and halo), which may also include cross-arms, to accommodate different numbers of conductors, or circuits of differing voltages, running to and from different directions, at different elevations.

6. The composition and size of THESL Poles varies according to the loads suspended and the operating environment, among other factors. For example, THESL Poles carrying multiple distribution feeders may need to be taller and larger in diameter than THESL Poles carrying a lesser load. A typical THESL Pole could have an overall length of 40 feet, of which 6 feet are buried for pole anchorage. Of the remaining 34 vertical feet above ground, 17.25 feet are required for clearance over ground level, 2 feet are available for non-distribution attachments, 3.25 feet are required as the zone of separation, and 11.5 feet are available for distribution equipment. Taller THESL Poles would have the same clearance and separation zones, but are buried more deeply, and have a slightly larger attachment zone, as well as a larger zone for distribution equipment. I attach to my affidavit as Exhibit "A" Figure 1, which depicts the vertical zones of a typical pole.

ii. THESL's Distribution System

7. The overhead distribution system in Toronto operates at voltages ranging up to 27,600 volts. All high voltage equipment is inherently dangerous and must be electrically insulated from supporting structures. In addition, safe limits of approach are defined and practiced on the overhead distribution system such that a zone of separation is required between high voltage equipment and any other attachments, as well as between any personnel working in proximity to the poles.

8. The distribution equipment attached to THESL Poles consists primarily of conductors (electrical cables), cross-arms and brackets to fasten the conductors to the poles, as well as insulators, transformers, switches, and system protection devices. Primary and secondary circuits, as well as up to 3 transformers, may also be attached to THESL Poles.

9. Although most equipment is suspended above ground, certain switch components, as well as conductors transitioning from overhead to underground, travel up the sides of poles from ground level. The various pieces of electrical distribution equipment can exert a substantial load on the THESL Poles. The poles and the equipment are also subject to natural forces such as wind and ice. These loads can act simultaneously in any downward and lateral directions.

10. THESL must therefore design, construct and maintain the overhead distribution system consistent with good engineering practice, industry standards and legislation, to ensure ongoing reliable operations and continued safety for the public and THESL employees. This includes:

a. complying with external standards, such as Ontario Regulation 22/04,[1] Technical Guidelines put out by the Electrical Safety Authority, Canadian Standards Association ("CSA") standard C22.3 No. 1 regarding Overhead Systems, the Ontario *Occupational Health and Safety Act* (and Regulations) and, just to name a few; and

b. creating internal supports and protocols that ensure that THESL treats any situation in which wires are down or improper contact is made with wires (for

---

[1] Electrical Distribution Safety, O Reg 22/04, made under the *Electricity Act, 1998*, SO 1998, c 15, Sch A. ("Ontario Regulation 22/04")

example, by fallen tree limbs or other objects) as an emergency for the purposes of dispatch and repair. Such supports and protocols include maintaining a call centre and rotational on-call crews at the ready 24 hours a day, 7 days a week, 365 days a year, as well as designing and following standardized emergency protocols.

11. Although THESL's overhead distribution system is designed and constructed to provide a long service life, that system is not static. THESL's distribution system is under constant pressure to change and adapt as a result of demands created by a number of factors including: connecting new customers, undertaking planned and emergency maintenance, replacing end-of-life assets, converting local area distribution system voltages, moving equipment to accommodate land use and infrastructure changes (such as widening roads), and repairing or replacing equipment damaged by collisions and other causes.

12. For example, much of THESL's system is located along heavily treed streets and other hydro rights-of-way. For us to manage planned maintenance and emergency response for these parts of its distribution system, we must trim trees and manage vegetation (for planned maintenance), as well as clear fallen limbs and re-erect distribution equipment (for emergency response).

13. In carrying out necessary maintenance and emergency work in these areas, THESL must balance two often competing objectives: system reliability and public safety on the one hand, and the public desire to interfere as little as possible with the urban tree canopy. Coordinating and executing these processes may also require us to move equipment off of poles and/or replace the poles altogether. Such efforts are of course undertaken in the vicinity of live power lines, which during emergency situations, may themselves be damaged or altogether down.[2]

14. Also relevant to the way in which THESL's distribution system is not static is the changing nature of THESL's own operations, such as the various asset management programs to improve reliability. Examples of such programs include:

---

[2] As a general matter, THESL's maintenance needs are continuous, ongoing and often complex. For example, in 2010, THESL spent $34.7 million on its maintenance programs. This is detailed at page 4 of THESL's Distribution Expenses Operations and Maintenance document (filed as Exhibit F1-T02-S01 in EB-2011-0144), an excerpt of which I attach to my affidavit as Exhibit "B".

a. moving rear-lot residential overhead systems to the front or street, and undergrounding the system;

b. increasing the amount of data-gathering equipment such as power line monitors;

c. adding equipment to improve outage response-time such as fault current indicators and automated switches; and

d. rebuilding legacy construction, such as the box style of pole-framing, to new standards.

B. <u>The CCTA Decision[3]</u>

15. THESL has developed policies and practices to accommodate wireline attachments pursuant to its obligations created by the CCTA Decision. I set out in further detail below the way in which THESL manages non-distribution attachments (“NDAs”) generally, and how it has accommodated wireline attachment requests since the CCTA Decision.

i. Non-Distribution Attachments Generally

16. In addition to maintaining its own distribution system equipment, THESL uses the THESL Poles to support NDAs, which fall into two broad categories: (a) communications attachments; and (b) non-communications attachments. Communications attachments comprise wireline attachments, such as telephone, cable television and fibre optic cables. Non-communications attachments include business improvement area decoration as well as surveillance and other devices such as rectifiers used to impress direct currents on underground pipe networks for the purpose of corrosion protection. Attached to my affidavit as Exhibit “C” is Figure 2 showing the breakdown of the classification of NDAs.

17. As the distribution utility and asset owner, THESL is responsible for managing the attachment, safe operation and removal or replacement of NDAs, and in doing so, must comply with various standards including Ontario Regulation 22/04. The Electrical Safety Authority, who has general responsibility for the safety of electrical installations in Ontario, has published

[3] I attach to my Affidavit as Exhibit “D” the Decision and Order rendered by the Ontario Energy Board in RP-2003-0249 dated March 7, 2005 (the “CCTA Decision”).

guidelines for use by distributors in interpreting and complying with the Regulation with respect to any work on a distribution system, including that involving NDAs (the "Guidelines"). I attach to my affidavit as Exhibit "E" and "F" respectively a copy of the Regulation and Guidelines.

18. Pursuant to the Regulation and Guidelines, THESL has created a system for receiving, reviewing and granting (or denying) applications for non-distribution pole attachments. In broad terms, THESL's process for reviewing permit applications is as follows:

a. the prospective attacher provides THESL certain prescribed information and drawings pertaining to the physical and other characteristics of the object(s) proposed to be attached;

b. THESL logs information provided by the prospective attacher into its database;

c. THESL confirms that the manner of attachment corresponds to standards that have been previously approved and certified by a professional engineer, and requires that the prospective attacher engage a professional engineer to review and if acceptable, approve and certify the manner of attachment;

d. THESL conducts a site visit to confirm the condition and characteristics of the pole to which an attachment is made;

e. THESL assesses each application for suitability and compliance with all the requirements – such requirements include confirmation of availability of space and non-interference with existing distribution equipment and other NDAs;

f. in the case that an attachment application is successful, the attacher submits an as-constructed drawing to THESL, which is then certified in compliance with applicable legislation and standards; and

g. THESL conducts a site visit and undertakes sampling inspections of the erected attachments.

19. Prior to 2009, THESL had a group of four dedicated employees who processed NDA applications, and carried out the activities associated with invoicing and contract management:

one clerk, two infrastructure occupancy representatives and one inspector who primarily handled temporary and decorative attachments, banners, baskets and lights. THESL also provided support to this group of employees by way of a supervisor and manager, as well as through the assistance of several other functional departments, such as THESL's Standards, Records Management and Construction groups.

20. In 2009 – the first year that THESL started receiving wireless attachment requests, and some four years after the CCTA decision was issued by the OEB - we experienced a spike in the number of telecommunications NDA applications. Whereas in 2007 and 2008, we received 103 and 418 attachment requests respectively, in 2009, we received 1135 requests. That number stayed relatively consistent throughout 2010, during which time we received 1029 telecommunications NDA requests.

21. Accordingly, in 2009, we brought on a summer student and a fall co-op student, each on four month terms. Our infrastructure occupancy team members also logged overtime hours during this period. In 2010, we added further resources to the group handling NDA attachments (in addition to overtime logged by existing group members): a one year intern position as well as seven contract staff. This intern and the contract staff were brought on to be fully dedicated to processing telecommunications NDAs.

22. The length of time that it takes to process any given application depends on the level of complexity of that application, with more complicated applications taking longer and slowing THESL's processing time for attachment applications in general. Applications which require make-ready work – work required to prepare a pole and/or distribution equipment for a new attachment – require significantly more time and planning to execute. For example, conductors may need to be raised or lowered to increase the amount of space available for communications attachments, guying or anchoring may need to be undertaken, or an entirely new pole that is taller or that can accommodate more load may need to be installed. Such make-ready work requires drawings and other documentation such as work orders to be prepared, and a crew to do the work. If the make-ready work requires excavation in the roadway (including sidewalks) for example, THESL must obtain a permit from the City of Toronto.

23. As discussed in paragraphs 11-14 above, THESL's distribution system is under constant pressure to change and adapt as a result of demands created by a number of factors. As host of the pole infrastructure, THESL is therefore required to take on a considerable ongoing operational and safety burden related to NDAs. This burden is in addition to the attachment application approval process described above.

24. For example, during the lifecycles of approved and installed attachments, THESL may be required to manage emergency repairs to, or planned relocation of, the poles supporting the attachments. When THESL undertakes such activities, it often must remove equipment from THESL Poles temporarily in order to complete repairs, or in cases where it is replacing a pole, permanently remove equipment from the displaced pole. THESL must coordinate with attachers to see that this work is done safely and properly, which requires for example, adding another layer of notification protocols to THESL's operating procedures. These are costs that THESL itself absorbs.

25. External pressures also bear on the burden that THESL experiences in relation to accommodating NDAs on THESL Poles. In 2010 for example, the CSA adopted provision 7.1 in its standard regarding Overhead Systems. Pursuant to provision 7.1, the CSA provides that distributors should use a non-linear calculation methodology for pole analysis in relation to wooden poles. Practically speaking, what this means for THESL is that in processing NDAs, we need to ask prospective attachers to provide us an additional loading analysis during the application process. As the adoption of the new standard is prospective, it also means that anytime we undertake an adjustment to THESL Pole infrastructure, we need to implement this standard. As a result, THESL's administrative, operational and safety burden for hosting NDAs is increased. I attach to my Affidavit as Exhibit "G" a copy of CSA Standard C22.3 No. 1-10 "Overhead Systems".

ii. Accommodating Wireline

26. From THESL's experience, electricity and telecommunication wireline systems share several common characteristics, including:

a. they are both largely composed of wire conductors or cables that convey electrical power or signals either by running continuously between successive poles or other points of suspension, or via underground ducts;

b. where the systems are overhead, they must be suspended securely above the public thoroughfare to prevent accidental damage and to ensure safety and reliability of service; and

c. they must physically extend to every end-user terminal point in order to provide their respective services.

27. These common characteristics create operational and safety efficiencies by virtue of their similarities, but also because wireline attachments themselves are largely uniform in design. The uniform nature of wireline attachments means that the needs and demands of those attachments are predictable and familiar to THESL, so creating standards for attaching them has been a relatively straightforward process.

28. The CCTA Decision is premised on the assumption that THESL Poles are the only option for wireline attachers in Toronto. For the reason that no other infrastructure meets the requirements of safety, access, and availability, distribution poles are a practical necessity (an "essential facility") for the suspension of above-ground wireline attachments. Accordingly, and pursuant to the CCTA Decision, THESL has granted wireline attachers access to THESL Poles on the basis of those attachments fitting within the communications space on THESL Poles and assuming approximately 2.5 attachments per pole.[4]

29. Pursuant to the CCTA Decision, THESL also bills wireline attachers a pole attachment fee of $22.35/pole/year. In addition to this, THESL has historically charged prospective telecom attachers a $95 application charge to recover its costs of processing those applications. THESL

[4] See CCTA Decision, at p. 4 and 10 (Exhibit "D" to my affidavit).

also charges, on a cost recovery basis, for all make-ready work required in order for a THESL Pole to host the attachment. Such make-ready work includes any changes, alterations, rearrangements or repairs of THESL Poles or attachments already on those poles.

30. Traditional wireline – the subject matter of the CCTA Decision - makes use of the communications space on THESL Poles and falls below THESL's electricity conductors.

31. The safety considerations relevant to THESL's assessment of potential wireline attachments include: satisfying itself that the size and weight of the attachment is appropriate for the particular pole configuration and in light of other distribution equipment or other NDAs already on the pole, as well as reviewing the manner of attachment and the likely effect of the attachment on existing pole equipment. In carrying out these assessments, THESL is guided by internal standards that govern matters such as the bonding between the cable messenger and the sheath or shield, the mounting hardware, as well as compliance with external standards including those imposed by the Electrical Safety Authority and legislation.

32. In the years 2006-2010, THESL received 473, 103, 418, 886 and 813 wireline attachment requests respectively. CANDAS has stated that of the applications submitted by Cogeco in 2009 and 2010, 303 were for the "wired" component that is necessary to support wireless attachments.[5] Accordingly, and assuming an approximately even distribution of Cogeco's wireless-supporting applications as between 2009 and 2010, the more accurate number of stand-alone wireline requests that THESL received for those years was 734 and 662 respectively.

C. <u>Wireless Attachments</u>

33. As I explain in further detail below, THESL's observation is that there are real and material differences between wireline and wireless NDAs. As a result, THESL has safety, operational and cost concerns with hosting wireless attachments.

---

[5] I attach to my affidavit as Exhibit "H" CANDAS' response to interrogatories of Board Staff dated August 16, 2011, question 1.1.

i. The Differences Between Wireline and Wireless

34. The major distinction signified by the term "wireless" (as compared with wireline) is that the equipment being supported is not composed primarily of cable which must run continuously between poles in order to function. Non-wireline communication attachments are effectively individual, free-standing "mini systems" that require several pieces of equipment to be accommodated on each THESL Pole. These mini-systems often take up space on THESL Poles well beyond the communications space expressly approved by the Ontario Energy Board in its CCTA Decision.[6]

35. Contained within this mini-system are wireless antennas as well as associated equipment that must be installed onto any given THESL Pole. This associated equipment may include power supply cabinets or boxes, cable to connect the cabinet to the antenna, cable to feed back into the communications network, and possibly a meter for electricity service.

36. Although the wireless pole attachments are like individual "mini systems", from THESL's experience, all wireless attachments also have a "wired" component as they require power supplies involving low-voltage electrical connections and also need to be connected to communications cables.

37. Wireless attachments also require THESL to feed a power supply, at a lower voltage, off the pole itself. Given the variability of wireless attachment configurations as well as the variability of THESL Pole configurations themselves, THESL must coordinate provision of this feed on a case-by-case basis.

38. From THESL's experience, there is no standard wireless communications attachment – the mini systems are not uniform in nature. Rather, wireless attachments are variable in size and configuration. Further, when mounted on distribution poles, wireless attachments typically occupy a much greater portion of pole space than wireline attachments.

---

[6] I attach to my affidavit as Exhibit "I" CANDAS' response to interrogatories of THESL dated August 16, 2011, questions 2(b), 38(a) and 45(a).

39. THESL's experience is also that wireless communications typically do not fall within the communications space appropriate for NDAs on THESL Poles. Wireless attachments use up space on THESL Poles well beyond the communications space provided for by the CCTA Decision.

ii. THESL's Safety and Operational Concerns with Hosting Wireless

40. Beyond the fundamental issue that wireless attachments are not included within the CCTA Decision, THESL has a number of concerns with attaching wireless attachments onto THESL Poles. Wireless attachments create unique issues that affect the safety, adequacy, reliability and quality of electricity service.

41. One such concern is that due to the non-uniform nature of wireless attachments and the case-by-case demands that they place on any given THESL pole, it is challenging for us to develop internal standards and operating procedures in order to streamline the administrative process of reviewing applications and attaching this emerging technology to THESL Poles.

42. For example, the variability of wireless attachment configurations, the quantity of equipment and the variety of THESL Poles and pole framing means that it takes comparatively more time for us to process wireless attachment applications due in part to the increased complexity of the equipment being attached.

43. Another concern THESL has is regarding the variability of wireless attachment configuration (including that the equipment often does not fit within the communications space) and the quantity of equipment that must be attached to any given THESL Pole. This means that wireless attachments tend to require more frequent and onerous make-ready work as compared with wireline attachments. Depending on the composition of the distribution equipment (and possibly other NDAs) on any given THESL pole, accommodating a wireless attachment may require creating additional space on a pole by moving around existing equipment, or in some cases, replacing the pole altogether.

44. Once a wireless attachment is in place on a THESL Pole, the size and quantity of equipment may make it very difficult if not impossible for THESL workers to climb THESL Poles safely. This "pole clutter" may also create obstructions for THESL workers when

performing pole maintenance in the ordinary course and during emergency repairs, meaning that additional THESL resources and protocols are required.

45. Such "pole clutter" may also increase wear and tear on THESL Poles, which accelerates THESL Pole deterioration. THESL Poles were not designed or installed with bearing the additional load of wireless attachments in mind. Pole attachments, if designed or installed incorrectly, can overload or damage a pole. Further, to the extent that wireless attachers may require holes to be drilled through THESL Poles to mount wireless communications attachments below the distribution zone, this could incrementally weaken those THESL Poles.

46. Further, THESL's experience is that wireless companies prefer to have their attachment antennas mounted on THESL Pole tops. However, installing wireless antennas on pole tops above energized electric facilities, creates a number of additional safety and operational concerns, including:

a. pole top attachments require workers to pass through energized lines to work on those attachments, posing a safety risk to those workers operating on THESL Poles;

b. antennas and other equipment could fall onto energized electric facilities as a result of factors including antenna design defects, faulty installation, weather conditions, trees or branches and automobile collisions with the pole;

c. where an object falls on distribution wires, this can result in electric system faults, resulting in customers experiencing extended service interruptions. Should a line fall to the ground, public safety could of course be compromised;

d. the installation of pole top antennas complicates the grounding that is required, and may create a higher risk of phase-to-ground faults, which could put THESL workers and the public at risk; and

e. for certain THESL Pole configurations (such as the "halo" arrangement, a diagram of which is attached to my Affidavit as Exhibit "J"), the existence of a pole top antenna would take a THESL conductor location away unless THESL replaces the pole with a taller one.[7]

iii. THESL's Cost Concerns with Hosting Wireless

47. The increased safety and operational burden that wireless attachments place on THESL also results in increased costs that THESL absorbs as indirect costs of hosting attachments. While we charge attachers for make-ready work in the ordinary course, the additional complexities posed by wireless attachments discussed above means that THESL staff and crews must in general spend more time and effort making special accommodation for those wireless attachments on THESL Poles. This inevitably increases our operating expenses.

48. One example of this is the processing of wireless attachment applications. At the time of the CCTA proceeding and Decision, wireless attachments to THESL Poles were not in THESL's purview. At the time, NDAs on THESL Poles were primarily comprised of streetlights and wireline communications devices and THESL did not receive any wireless attachment requests until 2009.

49. However, since the time of the CCTA Decision, and as described above at paragraph 20, THESL has witnessed a dramatic growth in the number of applications for NDAs, particularly for wireless attachments. Before 2008, THESL did not receive any wireless NDA applications. In 2009, THESL received 249 requests for wireless attachments, and through the third quarter of 2010, received 218**.** As I noted above at paragraph 32, CANDAS has stated that 303 of the wirelines applications submitted by Cogeco in 2009 and 2010 were for wired infrastructure to support those wireless attachment applications.

50. This recent surge in requests for telecommunications NDAs, particularly for wireless attachments, has placed a severe strain on THESL resources and has unavoidably lead to longer wait times for attachment approval. As discussed in my affidavit above at paragraphs 19-21, in order to manage the demand created by the increasing number of NDA requests, THESL has added more staff to its applications team. Should THESL add wireless attachments to its NDA

[7] Provision 5.10.2.2 of CSA Standard No.1-10, attached to my affidavit as Exhibit "G" (noted above), provides for minimum separation between a wireless communication antenna and a supply plant on a THESL Pole, and that wireless communications attachments shall not be attached between primary and secondary supply conductors.

program in any substantial way, THESL would be required to divert significantly more resources to manage that NDA demand.

D. THESL Pole Space is a Scarce and Valuable Resource

51. While as described above in paragraphs 11-14 above, THESL's distribution system itself is not static, the number of THESL Poles within that distribution system does not materially vary - there is essentially a fixed amount of THESL Poles and pole space.

52. THESL must balance the demands for THESL Pole space created by telecom attachers against those of City of Toronto and its agencies, such as the following:

a. Toronto Transit Commission: uses include support of its trolley suspension cables, transit stop signs and route schedules;

b. Toronto Police Service: uses include support of surveillance equipment;

c. Business Improvement Areas: uses include hanging decorative items such as banners, baskets and special event items (e.g. lights); and

d. City of Toronto: uses include suspension of traffic and pedestrian signalling equipment.

53. THESL Poles are also used to support the provision of energy delivery in the Toronto area – both for other parties, such as Enbridge, and for THESL's own like and future needs that serve its distribution system. For example, THESL's distribution infrastructure is used to support equipment that powers rectifiers for Enbridge, which provide corrosion control for gas pipelines.

54. Further, as THESL's own distribution system evolves, it may need to add additional circuits, which requires adding additional conductors to THESL Poles in order to increase electricity supply. As noted above, installing an attachment such as a pole top antenna above the energized primary conductors may result in taking a THESL conductor location away, unless THESL installs a taller pole. This situation would occur, for example, where THESL needs to relocate existing primary conductors (especially changing vertical construction to halo construction) higher up on a pole to make space for transformers, high-voltage cable risers, and Supervisory Control and Data Acquisition ("SCADA")-controlled switches related to grid automation.[8]

55. As discussed above, wireless attachments take up a significant amount of space on THESL Poles, and a larger amount of space in comparison to other NDAs. As a result, where a wireless attachment mini-system is attached to a THESL Pole, THESL's ability to use that pole for its own distribution needs and/or non-distribution projects is importantly curtailed.

E. <u>Miscellaneous CANDAS Allegations</u>

56. CANDAS has made numerous allegations about THESL and its conduct in the CANDAS application and supporting affidavits. THESL does not believe that a direct response to these allegations would be helpful for the purpose of this motion. THESL does however reserve the right to provide a full and complete response to these allegations as part of its evidence, should the matter proceed upon the conclusion of this motion.

57. I make this affidavit in support of THESL's motion for a Decision and Order of the Ontario Energy Board as noted below, and for no other or improper purpose:

a. that the CCTA Decision does not apply to wireless communications attachments;

b. that the Board refrain from exercising its powers on the basis that there is or will be competition in the market for siting of wireless communications attachments sufficient to protect the public interest;

---

[8] As detailed in THESL's Electrical Distribution Capital Plan (filed as Exhibit D1-T06-S06 in EB-2011-0144), and excerpt of which I attach to my affidavit as Exhibit "K", in addition to intending to replace older SCADA-MATE switches with updated ones, THESL also intends to add more SCADA-MATE switches to its distribution system for the purpose of improving system reliability and flexibility. See in particular sections 3.1.1 (p. 32-33) and 3.3.3 (p. 34).

c. denying the relief sought by CANDAS and dismissing CANDAS' application; and

d. such other relief as THESL may request and the Ontario Energy Board may deem appropriate.

SWORN BEFORE ME
at the City of Toronto,
in the Province of Ontario,
on September 1, 2011.

Original signed by Mary Byrne

Amanda Klein
A Commissioner, etc.

Mary Byrne

TORONTO HYDRO-ELECTRIC SYSTEM LIMITED
14 Carlton Street
Toronto, Ontario M5B 1K5

Tel: 416-542-3100
E-Mail: regulatoryaffairs@torontohydro.com

BORDEN LADNER GERVAIS LLP
Barristers and Solicitors
Scotia Plaza
40 King Street West
Toronto, Ontario M5H 3Y4

J. Mark Rodger

Tel.: 416-367-6190
Fax: 416-361-7088
E-mail: mrodger@blgcanada.com

Counsel to Toronto Hydro-Electric System Limited

TO: ONTARIO ENERGY BOARD

P. O. Box 2319
2300 Yonge Street
Toronto, Ontario
M4P 1E4

Kirsten Walli
Board Secretary

Tel.: 416-481-1967
Fax: 416-440-7656

This is **EXHIBIT "A"** referred to in the Affidavit of

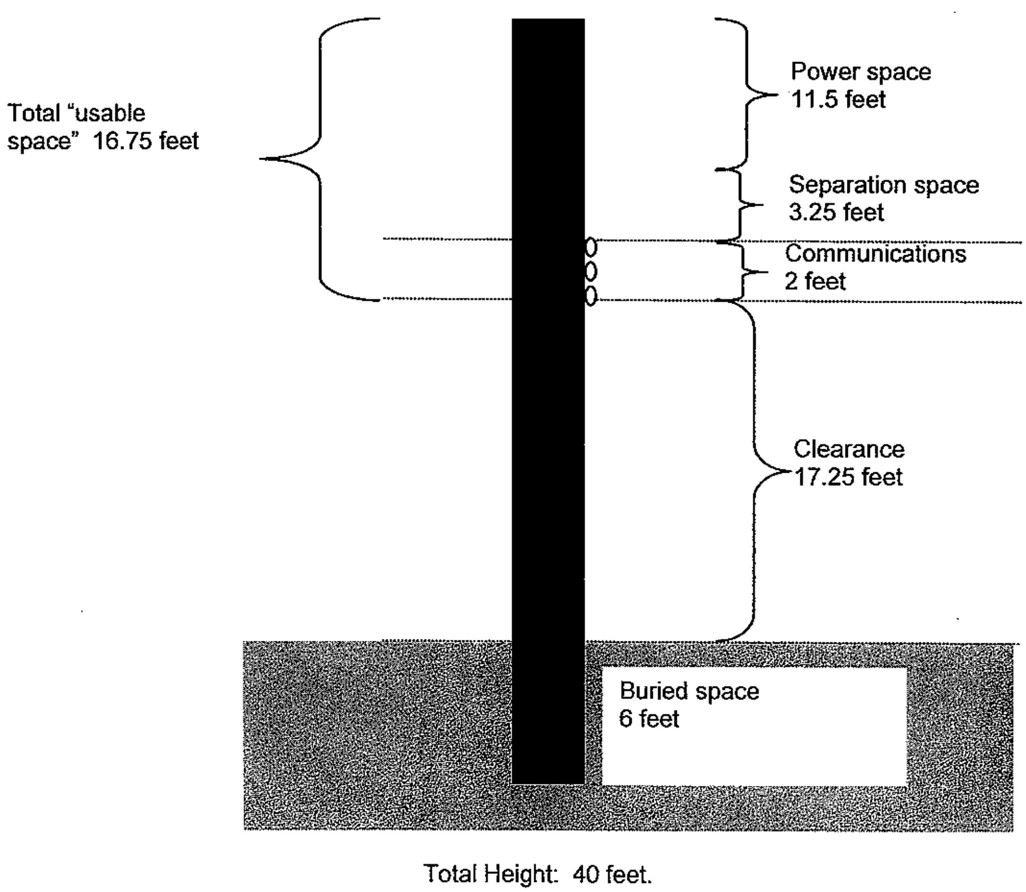
MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Figure 1. Vertical Zones of a Typical Hydro Pole



This is **EXHIBIT "B"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

DISTRIBUTION EXPENSES OPERATIONS AND MAINTENANCE

MAINTENANCE PROGRAMS

THESL's distribution plant asset maintenance programs are defined in its annual Plant Maintenance Manual. These programs are designed to emphasize preserving asset performance over the expected life of the asset, and maintaining public and employee safety. Reliability-Centered Maintenance ("RCM II"), discussed below, is the basis for the maintenance programs.

Maintenance tasks are designed to ensure that assets perform optimally within their operational lives. The maintenance programs for the test years are developed using models and assumptions that consider the following: the environment, health and safety regulations, historical failure rates, expected useful life, loading and manufacturers' operating and maintenance recommendations. They also take into consideration insurance underwriters' recommendations, industry best practices and acceptable risk tolerances. The maintenance programs that are scheduled for execution during 2012-2014 are defined in the THESL Plant Maintenance Manual and have been derived using the RCM II methodology.

MAINTENANCE APPROACH

The Aladon RCM II methodology is designed to establish the optimal maintenance program required to achieve a desired level of operational performance from an asset within its current operating context. The key elements are "desired performance" and "operating context." THESL maintains a given asset to perform as intended within the context of the THESL distribution system. This may mean, for example, that the maintenance recommended by the manufacturer is inappropriate for THESL's purposes. To illustrate, a station circuit breaker may be designed by the manufacturer to operate frequently; as a result, recommended maintenance might revolve around issues like contact wear or arcing damage. However, since THESL may operate breakers only a few times a year, maintenance is more appropriately focused on switch mechanism seizures due to inactivity. RCM II also provides an understanding of when it is better to replace a given asset, as opposed to performing corrective maintenance tasks to restore operational requirements. This model ensures that investments are cost effective and are focused on the critical distribution plant equipment. In comparison with traditional maintenance approaches, RCM II constitutes best practice for managing the functionality of the assets in operation.

THESL completed RCM II analysis of all major electrical asset classes in 2004 and its RCM II based maintenance program commenced in 2005. Since then, numerous reviews and refinements have taken place where field feedback is incorporated from both asset operators and maintainers, and the results of equipment performance analyses are considered.

Following the established maintenance model, THESL conducts four types of maintenance:

1) **Preventive Maintenance** typically involves cyclical inspection and maintenance tasks, which emphasize preserving asset performance over the expected life of the asset, and maintaining public and employee safety. Maintenance cycles are designed based on the mean time between failures for the failure modes of a given asset class and are intended to maintain the asset before it is statistically likely to experience a failure. An example of a preventive maintenance task is the inspection of overhead load interrupter switches, which is carried out on a three-year cycle.

2) **Predictive Maintenance** is the testing or auditing of equipment for a predetermined condition (or conditions) that anticipates failures and then undertaking maintenance

tasks to prevent those failures. For example, infrared scanning of components can identify incipient failures from elevated temperatures or sample testing of transformer oil can detect dissolved gasses or chemical compounds that occur when components begin to break down. Predictive maintenance is theoretically the least expensive maintenance alternative, but only when a predictive condition can be identified, practically monitored and corrected prior to failure.

3) **Corrective Maintenance** involves repairing or replacing equipment after a deficiency has been reported, such as actions taken after Emergency maintenance has restored power. For example, a faulted section of underground cable that had been isolated from the system during an emergency response would be unearthed and spliced out as a corrective maintenance action.

Corrective Maintenance actions may also result from deficiencies discovered during the execution of preventive or predictive maintenance tasks or other planned work. These tasks typically involve a short planning horizon since a portion of the distribution system is either faulted or isolated, or in a substandard condition thereby putting the distribution system at risk. Since defective equipment is a major contributor to SAIFI and SAIDI as demonstrated in Exhibit D1, Tab 7, Schedule 3, Corrective Maintenance emphasizes restoring assets to an acceptable level of operation, thereby improving system reliability.

4) Emergency Maintenance is the urgent repair or replacement of equipment when the equipment fails, causing a power disruption to THESL customers, such as replacing a switch fuse link. This type of maintenance may also involve an immediate response to a safety or environmental hazard. It emphasizes safe and prompt restoration of power to THESL customers.

Table 1: Maintenance Programs Costs ($ millions)

	2008 Actual	2009 Actual	2010 Actual	2011 Bridge	2012 Test	2013 Test	2014 Test
Preventive	8.6	10.8	13.3	10.3	10.5	11.9	13.7
Predictive	1.3	0.6	0.9	5.6	4.0	4.1	4.4
Corrective	10.4	13.9	14.1	11.4	14.8	15.2	15.7
Emergency	6.5	8.0	6.4	7.0	7.3	7.5	7.8
Total	**26.8**	**33.3**	**34.7**	**34.4**	**36.6**	**38.8**	**41.5**

PREVENTIVE MAINTENANCE

Preventive Maintenance is intended to maintain or improve customer service reliability, extend equipment life and ensure employee and public safety. Preventive Maintenance typically involves cyclical inspection and maintenance tasks, which emphasize preserving asset performance over the expected life of the asset, and maintaining public and employee safety. This work entails the inspection and overhaul of distribution assets and replacement of specific components at fixed intervals. Preventive Maintenance program requirements are prescribed in the THESL Annual Plant Maintenance Manual. Preventive Maintenance is derived from "RCM II", which is designed to determine the optimal maintenance tasks for assets within their operating context. Optimal, in this sense, refers to the most cost-effective option. This aims to ensure that resources spent on maintenance are spent where they will provide the greatest benefit, with respect to ensuring reliability, safety and compliance with environmental requirements.

As all preventive maintenance programs are derived from RCM II analyses, each program aims for the most cost-effective alternative for maintaining a specific class of assets. Increasing the maintenance cycle may not result in significant improvements; decreasing the maintenance cycle may result in drastic – and costly – failures.

THESL maintenance crews and qualified THESL contractors are responsible for carrying out, capturing data on, and reporting on various Preventive Maintenance activities as outlined in the THESL Annual Plant Maintenance Manual. The following sections discuss some of the types of equipment and activities that are addressed under preventive maintenance.

Overhead and Underground Distribution

The following are some of the activities performed in the Preventive Maintenance program:

- Three-Phase Gang-Operated Switches are maintained every three years to ensure safe and reliable operation during routine and emergency switching. This job entails identifying the physical and mechanical condition and verifying the correct blade alignment, blade penetration, travel stops and arc interrupter operation. The switches are then lubricated for efficient and proper operation. In 2010, the budget for overhead switch maintenance was increased in an effort to address the fact that, historically, switches have been one of the largest contributors the overhead CI (Customers Interrupted), as shown in the Table below.

This is **EXHIBIT "C"** referred to in the Affidavit of

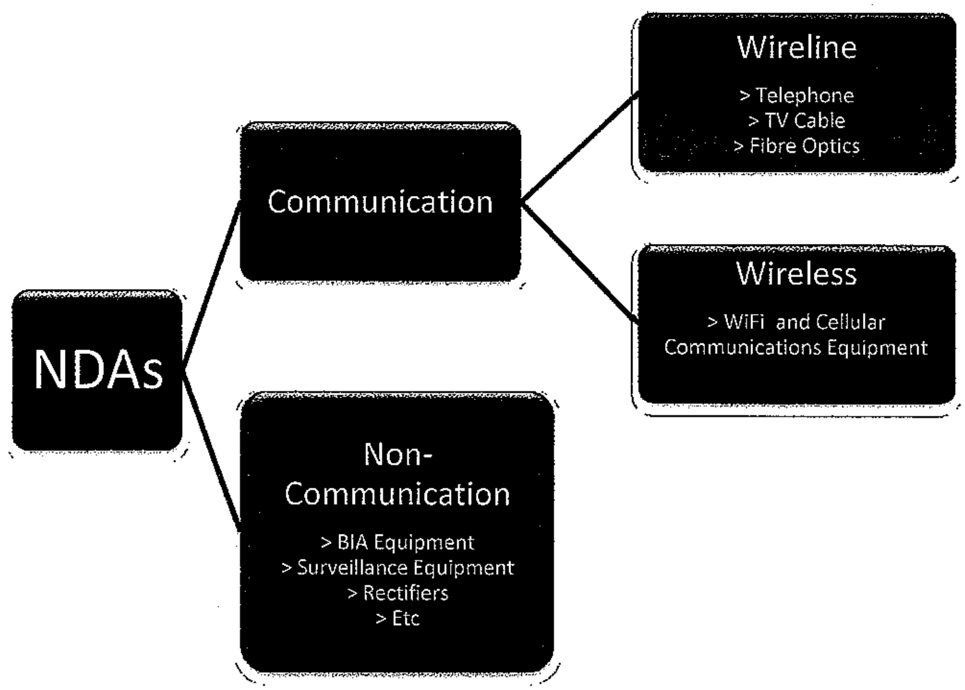
MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Figure 2. Classification of NDAs



This is **EXHIBIT "D"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Ontario Energy Board

Commission de l'Énergie de l'Ontario

Ontario

RP-2003-0249

IN THE MATTER OF the *Ontario Energy Board Act 1998*, S.O.1998, c.15, (Schedule B);

AND IN THE MATTER OF an Application pursuant to section 74 of the *Ontario Energy Board Act, 1998* by the Canadian Cable Television Association for an Order or Orders to amend the licenses of electricity distributors

BEFORE: Gordon E. Kaiser
Vice Chair and Presiding Member

Paul Sommerville
Member

Cynthia Chaplin
Member

DECISION AND ORDER

The Applicant, Canadian Cable Television Association ("CCTA") seeks access to the power poles of the regulated electricity distribution utilities in Ontario for the purpose of supporting cable television transmission lines. Specifically, the CCTA is seeking an Order under section 74(1) of the *Ontario Energy Board Act* which would amend the licences of these utilities in a fashion that would specify the uniform terms of access including a province-wide uniform rate or pole charge for such access.

In the past, the CCTA members have rented space on the utilities' poles under private contract. That contract came to an end in 1996. Since then, the parties have been unable to reach further agreement with respect to rates.

Background

In early 1997, the CCTA applied to the Canadian Radio and Telecommunications Commission ("CRTC") to set a charge for access by cable companies to the poles of the Ontario electricity distributors. After a lengthy proceeding, the CRTC set an annual pole charge of $15.89.[1]

The Ontario Municipal Electric Association ("MEA") appealed that decision to the Federal Court of Appeal which held that the CRTC did not have statutory authority under the Telecommunications Act to regulate access by cable operators and telecommunication carriers to power poles.[2]

On further appeal by the CCTA the Supreme Court of Canada upheld the Federal Court of Appeal decision.[3] Given the Court's decision that the CRTC lacked jurisdiction, the CCTA filed an application with this Board on December 16, 2003 on behalf of the twenty-three cable companies that operate in Ontario. None of the parties questioned the jurisdiction of this Board.

The issues before this Board in this proceeding are as follows :

1. Is it necessary that this Board set access charges?
2. Which parties should have access?
3. What is the appropriate methodology?
4. How many attachers should be assumed in calculating the rate?
5. Should there be a province-wide rate?
6. What costs should be used in calculating the rate?
7. Should new licence conditions impact existing contracts?

The Need to Regulate Access Charges

Part VII Application - Access to supporting structures of municipal power utilities - CCTA v. MEA et al - Final Decision, Telecom Decision CRTC 99-13, 28 September 1999. [hereinafter "Telecom Decision CRTC 99-13"]

Barrie Public Utilities v. Canadian Cable Television Assn., [2001] 4 F.C. 237.

Barrie Public Utilities v. Canadian Cable Television Assn., 2003 SCC 28.

The CCTA Application is opposed by the Electricity Distribution Association ("EDA") and the Canadian Electricity Association ("CEA"). The EDA represents virtually all licensed electricity distributors in this province (sometimes referred to as LDCs) while the CEA is a national association representing electricity distributors, generators and transmitters. The position of these two parties is supported by Hydro One Networks Inc., Hydro One Brampton Networks Inc., and Hydro One Remote Communities Inc.

The position of the EDA *et al* is that regulatory intervention by this Board is not necessary. The argument largely is that the Applicant has not demonstrated that there has been a systematic abuse of monopoly power and absent that showing, the Board should allow the parties to continue to negotiate.

There has been some evidence on both sides with respect to abuse. In the end the CCTA says that the electricity distributors do have monopoly power and the fact that the parties have been unable to come to an agreement for over a decade demonstrates the exercise of that monopoly power whether this results in abuse or not.

The Board agrees. A showing of abuse is not necessary to justify the intervention of this Board in this matter. The fact is the parties have been unable to reach an agreement in over a decade. This degree of uncertainty is not in the public interest.

The Board agrees that power poles are essential facilities. It is a well established principle of regulatory law that where a party controls essential facilities, it is important that non-discriminatory access be granted to other parties. Not only must rates be just and reasonable, there must be no preference in favour of the holder of the essential facilities. Duplication of poles is neither viable nor in the public interest.

The Board concludes that it should set access charges.

The EDA *et al* further submits that if the Board is going to set rates it should set a range of rates based on its proposed methodology as opposed to a specific rate. The CCTA opposes this. The CCTA argument is that a range of rates would simply lead to continued delay, that monopoly power would continue to be exerted and in fact, the upper range would become the rate. In another words, the bargaining power of the cable companies would be as deficient with a range of rates as it is at present. The Board accepts this view. There is no rationale for a range of rates in the current circumstances.

Who should have access?

On this issue, the parties are in agreement. In the Settlement Agreement of October 19, 2004, all parties agreed that if the Board does set access conditions, these conditions should apply to access to the communications space on the LDC poles by all Canadian Carriers as defined in the Telecommunications Act and cable companies. The only exception is that these conditions would not apply to the current joint use agreements between telephone companies and electricity companies that grant reciprocal access to each others poles.

This Board has accepted the settlement agreement in this regard. In addition, the Board has heard submissions to the effect that the LDCs agree that their own telecommunication affiliates would access poles on the same conditions as other users of the communications space. The LDCs also confirmed that all users of the communications space should pay the same charge.[5]

This is an important clarification. This market is changing rapidly and industries are converging. Cable companies are now providing the telecommunication services just as the electricity distributors enter this industry. The fact that the two groups that have been warring over the past decade are fast becoming competitors is an additional reason for the Board to intervene and establish clear guidelines. From this Board's perspective, it is equally important that costs be properly allocated and that the electricity distributor (and ultimately, the electricity ratepayer) receives its fair share of revenue.

What is the appropriate methodology?

There are two elements to the proposed rate. The first is the incremental or direct costs incurred by electricity distributors that results directly from the presence of the cable equipment. Second, there are common or indirect costs which are caused by both parties. The parties agree that the direct or incremental costs should be borne by the cable companies.

The dispute relates to what share of the common cost each parties should pay. The cable companies say the portion of the fixed or common cost they should bear should be based on the cable companies "proportionate use" of the usable space on the pole. Electricity distributors claim that the portion of the common cost each of the parties bear should be equal. In other words, the common cost should be divided equally among attachers on a "per capita" basis.

Tr. Vol. 2 at paras. 800 and 804.

Both parties called experts. The cable companies called Donald A. Ford while the electricity distributors called Dr. Bridger Mitchell. Reply evidence for the CCTA was presented by Patricia Kravtin and Paul Glist. All witnesses were qualified as experts.

The CCTA Application seeks a pole attachment rate of $15.65, a similar amount to that decided by the CRTC. The rates proposed by the EDA are substantially higher.

The principal argument advanced by the cable companies is that proportionate use is the methodology adopted by the CRTC and it has also been followed elsewhere in Canada and the United States. They point out that there have been numerous reviews of this rate methodology and the methodology has never been set aside.[6]

The response of the electricity distributors is that these rates are unduly low and are driven by considerations of telecommunication policy. In particular, they were designed to foster competition in that sector. The witnesses, however, were unable to point to any particular articulation of that policy goal as the justification for the rate levels at least in the Canadian context.

In Canada, the two decisions that follow the CRTC decision have in fact been divided on this issue. The Alberta Energy Utility Board ("AEUB") established a pole attachment rate of $18.34 in 2000 using the per capita approach.[7] The Nova Scotia Utility and Review Board ("NSURB") set a rate of $14.15 in 2002 following the CRTC approach.[8] The Nova Scotia Board did point out however, they had not conducted any cost allocation studies on their own.

An additional argument to support the lower rate advanced by the cable companies is that they are only tenants while the electricity distributors own the poles. They argue that pole ownership confers a benefit.

The electricity distributors deny this, claiming that ownership has costs; they have

---

FCC v Florida Power Corp. 480 US 245, (1987); In the Matter of Alabama Cable Telecom Association v Alabama Power Corp.; 16 FCC 12, 12, 209 (2001)

TransAlta Utilities Corporation, Decision 2000-86 (Alberta Energy and Utilities Board), December 27, 2000 online: <http://www.eub.gov.ab.ca/bbs/documents/decisions/2000/2000-86.pdf>.

In the Matter of the Public Utilities Act and In the Matter of an Application by Nova Scotia Power Incorporated for Approval of an Increase in its Pole Attachment Charge, Decision 2002 (Nova Scotia Utility and Review Board) NSUARB-1, January 24, 2004.

to install poles whether they have an attacher or not and may face stranded assets. In the end, the Board is not persuaded that the ownership of the poles should effect the level of rates. The Board agrees with the electricity distributors that the impact of ownership is neutral.

The CEA argues that electricity distributors should be allowed to raise the rates charged to the cable companies because cable companies are now generating "massive new sources of revenue" from the use of electricity distribution plant. In particular, they point out that revenues from high speed internet service have increased from $0 in 1995 to over $900 million annually by 2003. The CEA requested that the Board infer that a large portion of these revenues are from Ontario cable operations. The Board notes that there is very little evidence on this issue. Moreover, the Board believes that the methodology used to determine rates should be based on cost recovery, not some form of revenue sharing.

Another rationale advanced by the cable companies is that it makes no sense to have different methodologies for setting rates on power poles compared to telephone poles. The argument is that since the CRTC methodology is used to price access to telephone poles, the same methodology should be followed in pricing access to power poles. The Board is not convinced. This Board may have a different policy rationale than the CRTC particularly in terms of the electricity ratepayer and the serving utility. In any event, it is worth noting that the rental charge paid by the cable companies for access to telephone poles is $9.60 per pole. This is certainly not the rate being advanced by the cable companies in this proceeding.

The most persuasive argument for equal sharing of the common cost is the practice that appears to take place when parties are in position of equal bargaining power. The LDCs point to the reciprocal agreements between the telephone companies and the
power companies that have existed for a number of years. Under those agreements, each of the regulated utilities has access to the other's poles. They essentially split the common cost equally.

The cable companies question this proposition. They argue that these are regulated entities that have a bias to invest more than optional amounts of capital based on the Averch Johnson principle. [9] The Board notes however, that both sides face the same incentive in terms of investing capital in rate base assets. It can reasonably be assumed that the telephone companies and the power companies are in an equal bargaining position and the resulting solution is a meaningful guideline.

The CCTA responds that its members are not in an equal bargaining position. In

---

Harvey Averch and Leland L. Johnson, "Behaviour of the Firm under Regulatory Constraint," *Amer. Econ. Rev.* (December 1962) LII: 1052-1069.

the Board's view, that is not relevant. The free and open negotiation between the telephone and power companies is offered as a proxy for a competitive market solution. No party holds an advantage over the other or is in a position to exercise monopoly power.

For many years, electricity and telephone companies in at least four provinces have openly negotiated reciprocal access agreements to telephone and power poles. In all cases, these agreements appear to reflect equal allocation of common costs. This suggests that the per capita or equal sharing methodology is the appropriate one. Moreover, as more and more parties attach to these poles, the notion that there is a discrete portion of space to be allocated to each becomes more problematic.

The Board recognizes that a case can be made for both the proportionate use and the equal sharing methodology. On balance, however, the Board prefers the equal sharing theory for the reasons stated.

How many attachers should be assumed?

When the CCTA filed its Application, it assumed two attachers. This position was amended in Final Argument when 2.5 attachers was proposed. The Reply Argument of the CCTA appears to revert back to two attachers with reference to the CRTC rate of $15.65.

Two attachers were assumed in the CRTC decision. The industry however, has changed dramatically over the last five years. There is evidence that in one municipality there are as many as seven different parties seeking attachment. There is also evidence that poles are used by municipalities for the purpose of street lighting and traffic lights.

In addition, an increasing number of telecommunication providers are entering the market to compete with incumbent telephone company providing voice and data services. A number intervened in this proceeding and by virtue of the settlement agreement will have access to the poles in question. Finally, in a number of major markets the Ontario electricity distributors have established their own affiliates to offer telecommunication services. The LDCs have agreed that these affiliates should pay the same rates as the other parties attaching to the power poles. There is also evidence that Hydro One which accounts for a third of the poles in the province has more than two attachers.

The Board considers 2.5 attachers to be reasonable. Things have changed since the days of the CRTC decision. If anything, there will be more than 2.5 attachers in the future.

Should there be a province-wide rate?

The cable companies argued for a standard province-wide rate. There is precedent for this in terms of the CRTC decision as well as the Nova Scotia and Manitoba decisions. A province-wide rate has the advantage that it is simple to administer. This is certainly one of the goals the Board hopes to achieve in this decision. Moreover, the cost data at the individual LDC level is incomplete. Calculating these costs for ninety different utilities will be a challenge for all concerned.

This is not to say there should not be relief available for electricity distributors who feel the province-wide rate is not appropriate to their circumstances. Any LDC that believes that the province-wide rate is not appropriate can bring an application to have the rates modified based on its own costing. Absent any application, the province-wide rate will apply as a condition of licence, as of the date of the Order.

What costs should be used to calculate the rate?

The annual pole rental charge of $15.65 proposed by the CCTA is a function of both the direct and the indirect cost as set out in Appendix 1. The direct costs consist of the administration cost and the loss of productivity. The total direct cost estimate of $2.61 is based on the CRTC decision.

The EDA claims that there is no reason why the Board should use a $1.92 estimate of loss of productivity as advanced by the CCTA. The EDA points to different data from five different LDCs which range from $0.67 per pole in the case of Hydro One Networks to $5 per pole in the case of Guelph Hydro. References are also made to the evidence of Manitoba Hydro filed by the CEA which calculated a loss of productivity of $6.39 per joint use pole.

There is no question that there is a wide variation in these costs and estimates. The EDA recommends that if this Board determines that it should use the CCTA model to arrive at a uniform annual pole charge, the Board should use the highest Ontario data available to set that uniform rate. That rate would be $32.81 using the Toronto Hydro data and the productivity loss estimate for Guelph Hydro. The Board disagrees and concludes that province-wide representative cost data are more meaningful in the circumstances. For the purposes of calculating the rate in this proceeding, the Board has adopted the direct costs set out in the CCTA application and reproduced in Appendix 1.

Next there are the indirect costs which consist of the net embedded cost per pole plus depreciation, maintenance expense and carrying costs. Again a wide range of costs were proposed by the EDA depending on the particular utility chosen. The Board has concluded that the depreciation, maintenance and carrying costs proposed by the CCTA are representative as set out in Appendix 1.

The CCTA's proposed rate is based on an average net embedded pole cost of $478. This embedded cost is derived from material filed by Milton Hydro in the proceeding leading to the Telecom Decision of the CRTC 99-13 and is supported by the evidence of Hamilton Hydro in this proceeding that the embedded pole cost is $477.47.

EDA argues that local costs vary significantly and if the Board considers it appropriate to set a uniform rate, the rate should reflect the cost of the utilities having the highest embedded pole cost. The EDA then submits that the parties should be free to apply to the Board for a lower rate where they can demonstrate lower costs.

While the Board recognizes local costs vary, there are advantages to having a province-wide rate. That rate should to a maximum extent possible, be based upon representative cost. The Board accepts the CCTA's estimated average net embedded pole cost of $478.

The rate proposed by the CCTA assumed a pre-tax weighted average cost of capital of 9.5%. In response to an undertaking, the CCTA provided a revised weighted average cost of capital based upon a debt equity ratio of 50/50, an interest rate of 7.25% and a return on equity of 9.88% as provided for in the Board's current Rate Handbook. This cost of capital applies to distributors with a rate base of less than $100 million. Given that a large majority of distributors in the province have less than this amount, the Board believes that this new weighted average of capital is an appropriate one to use in calculating a province-wide rate.

Calculation of the rate

To calculate the rate, it is necessary to define the number of attachers as well as the embedded pole costs discussed above. It is also important to define the spacing on a typical pole.

The CCTA proposal assumes a typical pole height of 40 feet with two feet of communications space, 3.25 feet of separation space and 11.50 feet of power space. Mr. Wiebe, on behalf of CEA proposed slightly different space allocations. The CCTA argues that the space allocations adopted by Mr. Ford are virtually identical to those put forward by the Municipal Electric Association in the CRTC proceeding. In addition, the EDA put forward a model agreement developed cooperatively by a number of LDCs (the Mearie Group) where the assumptions regarding space allocation for a typical 40 foot pole were identical to those used by Mr. Ford. The Board finds that the CCTA estimates are acceptable.

As stated, the Board believes that a single province-wide rate is in the public interest. As indicated, the Board believes its more realistic to use 2.5 as the number of attachers. The Board agrees with the EDA and CEA that the common costs should be shared equally among all attachers. On these principles and the cost data described above, the annual pole charge is $22.35 per attacher as set out in Appendix 2.

Should there be a standard form of agreement?

Under the Settlement Agreement, the parties agree to negotiate the terms and conditions once the Board has made its determination as to the rate. The parties agree to report back to the Board in four months as to the progress of these negotiations. The Board accepts this approach.

Impact on existing contracts

In the Settlement Agreement all parties with one exception, agreed that any new rate set by the Board should not apply to existing contracts. The rate would only apply when the current term of existing contracts expired. Where no contract exists, the licence conditions would apply immediately.

The acceptance of this position appears to be driven by the fact that most existing contracts provide for retroactive rate adjustment in the event this Board determines a rate.

The CCTA states that it would not object to a Board ruling that existing contracts without a retroactivity clause are immediately subject to the Board's decision regarding new licence conditions. They claim however, that few contracts do not have retroactivity provisions.

MTS objects to the Settlement Agreement and submits that any pole access rates set by the Board should be applied to all existing contracts not just those with retroactivity clauses. The Board will provide that the new rates and conditions resulting from this decision will apply immediately to those agreements without a retroactivity clause. Those are apparently few in number. This should provide immediate relief to those who are unable to benefit from a retroactivity provision.

THE BOARD ORDERS THAT:

The licence conditions of the electricity distributors licenced by this Board shall as of the date of this Order be amended to provide that all Canadian carriers as defined by the Telecommunications Act and all cable companies that operate in the Province of Ontario shall have access to the power poles of the electricity distributors at the rate of $22.35 per pole per year.

Dated at Toronto, March 7, 2005.

Original signed by

____

Gordon E. Kaiser
Vice Chair and Presiding Member

Appendix 1: CCTA Recommended Charge (2 Attachers)

	Price Component - Per Pole	*$*	*Explanation*
	DIRECT COST		
A	Administration Costs	$0.69	CRTC estimate 1999 $0.62, plus inflation
B	Loss in Productivity	$1.92	MEA estimate 1991 = $3.08, plus inflation, and divided between two pole attachers
C	Total Direct Costs	$2.61	A + B
	INDIRECT COSTS		
D	Net Embedded Cost per pole	$478.00	Milton Hydro 1995 = $478
E	Depreciation Expense	$31.11	Milton Hydro 1995 = $31.11
F	Pole Maintenance Expense	$7.61	Milton Hydro 1995 = $6.47, plus inflation
G	Capital Carrying Cost	$45.41	Pre-tax weighted average cost of capital 9.5% applied to net embedded cost per pole (D)
H	Total Indirect Costs per Pole	$84.13	E+F+G
I	Allocation Factor	15.5%	CRTC allocation
J	Indirect Costs Allocated	$13.04	H x I
K	Annual Pole Rental Charge	$15.65	C + J

Appendix 2: 2.5 Attachers - Shared Costs Evenly Spread Amongst All Users

	Price Component - Per Pole	*$*	*Explanation*
	DIRECT COST		
A	Administration Costs	$0.69	CRTC estimate 1999 $0.62, plus inflation
B	Loss in Productivity	$1.23	MEA estimate 1991 = $3.08, plus inflation, and divided between 2.5 pole attachers
C	Total Direct Costs	$1.92	A + B
	INDIRECT COST		
D	Net Embedded Cost per pole	$478.00	Milton Hydro 1995 = $478
E	Depreciation Expense	$31.11	Milton Hydro 1995 = $31.11
F	Pole Maintenance Expense	$7.61	Milton Hydro 1995 = $6.47, plus inflation
G	Capital Carrying Cost	$54.59	Pre-tax weighted average cost of capital 11.42% applied to net embedded cost per pole (D)
H	Total Indirect Costs per Pole	$93.31	E+F+G
I	Allocation Factor	21.9%	Allocation based on 2.5 attachers
J	Indirect Costs Allocated	$20.43	H x I
K	Annual Pole Rental Charge	$22.35	C + J

This is **EXHIBIT "E"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Electricity Act, 1998
Loi de 1998 sur l'électricité

ONTARIO REGULATION 22/04

Amended to O. Reg. 149/05

ELECTRICAL DISTRIBUTION SAFETY

Notice of Currency:* This document is up to date.

*This notice is usually current to within two business days of accessing this document. For more current amendment information, see the Table of Regulations – Legislative History Overview.

This Regulation is made in English only.

Interpretation

1. In this Regulation,

"Authority" means the Electrical Safety Authority;

"authorized person" means a competent person authorized by a distributor to have access to areas containing, or structures supporting, energized apparatus or conductors;

"barriered" means separated by clearances, burial, separations, spacings, insulation, fences, railings, enclosures, structures and other physical barriers, signage, markers or any combination of the above;

"competent person" means a person who,

(a) is qualified because of knowledge, training and experience,

(i) to perform specific work, or

(ii) to organize work and its performance,

(b) has knowledge of any potential or actual danger to health or safety in the workplace in relation to the work, and

(c) is familiar with section 113 of the Act and the regulations made under it, and with the *Occupational Health and Safety Act* and the regulations made under that Act, that apply to the work;

"contractor" means any person who performs work on electrical equipment or an electrical installation;

"disconnecting means" means a device, group of devices or other means whereby the conductors of a circuit can be disconnected from their source of supply;

"distribution line" means an electricity distribution line, transformers, plant or equipment used for conveying electricity at voltages of 50,000 volts or less;

"distribution station" means an enclosed assemblage of equipment, including but not limited to switches, circuit breakers, buses and transformers, through which electrical energy is passed for the purpose of transforming one primary voltage to another primary voltage;

"effectively grounded" means permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages that may result in undue hazard to persons;

"electrical equipment" means any apparatus, appliance, device, instrument, fitting, fixture, machinery, material or thing used in or for, or capable of being used in or for, the distribution, supply or utilization of electric power or energy, and, without restricting the generality of the foregoing, includes any assemblage or combination of materials or things which is used, or is capable of being used or adapted, to serve or perform any particular purpose or function when connected to an electrical installation, notwithstanding that any of such materials or things may be mechanical, metallic or non-electric in origin;

"electrical installation" means the installation, repair, replacement, alteration or extension of any wiring or electrical equipment that forms part of a distribution system;

"ESC" means the Electrical Safety Code referred to in Ontario Regulation 164/99;

"live" means electrically connected to a source of voltage difference or electrically charged so as to have a voltage different from that of the earth;

"ownership demarcation point" means the point,

(a) at which the distributor's ownership of a distribution system, including connection assets, ends at the customer, and

(b) that is not located beyond,

(i) the first set of terminals located on or in any building, or

(ii) an electrical room or vault in a building where the electrical room or vault is of tamperproof construction, bears a sign to indicate that it is an electrical room or vault and is accessible only to authorized persons;

"primary distribution line" means a distribution line conveying electricity at more than 750 volts but not more than 50,000 volts phase to phase;

"professional engineer" means a person who holds a licence or a temporary licence under the *Professional Engineers Act*;

"secondary distribution line" means an electricity distribution line conveying electricity at 750 volts or less phase to phase;

"vault" means an isolated enclosure, either above or below ground, with fire-resistant walls, ceilings and floors in which transformers and other electrical equipment are housed. O. Reg. 22/04, s. 1.

Application

2. (1) Subject to subsection (2), this Regulation applies with respect to distribution systems regardless of when they came into existence. O. Reg. 22/04, s. 2 (1).

(2) Sections 3, 4, 5, 6, 7, 8, 9 and 13 apply with respect to distribution systems that are designed or come into existence on or after February 11, 2004 and with respect to distribution systems that existed before that date in respect of repairs, alterations or extensions made to those systems. O. Reg. 272/04, s. 1.

(3) This Regulation applies with respect to a distribution system as far as the ownership demarcation point and no further. O. Reg. 22/04, s. 2 (3).

(4) The ESC, and not this Regulation, applies with respect to,

(a) electrical installations and electrical equipment located beyond the ownership demarcation point, except for revenue metering equipment and associated equipment, current transformers, voltage transformers and remote terminal units;

(b) electrical installations and electrical equipment that are located in buildings, or rooms in buildings, used as offices, washrooms, cafeterias, warehouses, garages, machine shops and recreational facilities if the installations and equipment belong to the distributor. O. Reg. 22/04, s. 2 (4).

(5) This Regulation, and not the ESC, applies to distributors who are licensed to own or operate a distribution system under Part V of the *Ontario Energy Board Act, 1998*. O. Reg. 149/05, s. 1.

(6) The ESC, and not this Regulation, applies to distributors, other than distributors who are licensed to own or operate a distribution system under Part V of the *Ontario Energy Board Act, 1998*. O. Reg. 149/05, s. 1.

Same, change of ownership

3. (1) If there is a change to the ownership demarcation point or a transfer of ownership of a distribution system, or part thereof, to a person that is not a distributor, the system or part transferred shall be, on completion of the transfer, subject to the requirements of the ESC. O. Reg. 22/04, s. 3 (1).

(2) Prior to the change to the ownership demarcation point or the transfer of ownership, the distributor shall,

(a) notify the Authority of the proposed change or transfer; and

(b) notify the non-distributor transferee that, on completion of the change or transfer, the distribution system or part transferred becomes subject to the requirements of the ESC. O. Reg. 22/04, s. 3 (2).

(3) Prior to the change to the ownership demarcation point or the transfer of ownership, a report identifying any modifications to the distribution system or part to be transferred that are required to ensure that the system or part will be in conformance with the requirements of the ESC shall be provided to the non-distributor transferee and to the Authority. O. Reg. 22/04, s. 3 (3).

Safety standards

4. (1) All distribution systems and the electrical installations and electrical equipment forming part of such systems shall meet the primary safety standard set out in subsection (2) by meeting the safety standards set out in subsections (3), (4), (5) and (6). O. Reg. 22/04, s. 4 (1).

(2) All distribution systems and the electrical installations and electrical equipment forming part of such systems shall be designed, constructed, installed, protected, used, maintained, repaired, extended, connected and disconnected so as to reduce the probability of exposure to electrical safety hazards. O. Reg. 22/04, s. 4 (2).

(3) All electrical installations operating at 750 volts or below that are not a direct part of a distribution system shall meet the following safety standards:

1. Operating electrical equipment shall be maintained in proper operating condition.

2. Adequate space shall be provided around electrical equipment for proper operation and maintenance.

3. Live conductors shall be adequately insulated or barriered to prevent inadvertent contact.

4. Persons who have reason to work on electrical wiring or touch live conductors shall have ready access to a means to disconnect the live conductors before working on the wiring or touching the conductors.

5. Disconnecting means shall effectively disconnect and be operable without undue hazard.

6. Metal parts of an installation that are not intended to be energized shall be effectively grounded.

7. Electrical installations shall be carried out so as to minimize the possibility of contributing to or causing a fire or explosion.

8. Electrical installations shall be carried out so as to minimize the possibility of insulation damage or deterioration. O. Reg. 22/04, s. 4 (3).

(4) All overhead distribution lines, including secondary distribution lines, shall meet the following safety standards:

1. Operating electrical equipment shall be maintained in proper operating condition.

2. Adequate space shall be provided around electrical equipment for proper operation and maintenance.

3. Energized conductors and live parts shall be barriered such that vegetation, equipment or unauthorized persons do not come in contact with them or draw arcs under reasonably foreseeable circumstances.

4. Metal parts of the installation that are not intended to be energized and that are accessible to unauthorized persons shall be effectively grounded.

5. Structures supporting energized conductors and live parts shall have sufficient strength to withstand the loads imposed on the structure by electrical equipment and weather loadings. O. Reg. 22/04, s. 4 (4).

(5) All underground distribution lines, including secondary distribution lines, shall meet the following safety standards:

1. Operating electrical equipment shall be maintained in proper operating condition.

2. Adequate space shall be provided around electrical equipment for proper operation and maintenance.

3. Energized conductors and live parts shall be barriered such that equipment or unauthorized persons do not come into contact with them or draw arcs under reasonably foreseeable circumstances.

4. Metal parts of the installation that are not intended to be energized and that are accessible to unauthorized persons shall be effectively grounded.

5. Parts of the distribution system in proximity to the inside walls of a swimming pool shall be installed in such a way as to minimize the possibility of voltage gradients in the swimming pool.

6. Parts of a distribution system in proximity to propane tanks and natural gas pipelines shall be installed in such a way as to minimize the possibility of explosions under normal circumstances and operating conditions. O. Reg. 22/04, s. 4 (5).

(6) Distribution stations shall meet the following safety standards:

1. Operating electrical equipment shall be maintained in proper operating condition.

2. Adequate space shall be provided around electrical equipment for proper operation and maintenance.

3. Metal parts of the installation that are not intended to be energized and that are accessible to unauthorized persons shall be effectively grounded.

4. Energized conductors and live parts shall be barriered such that equipment or unauthorized persons do not contact them or draw arcs under reasonably foreseeable circumstances.

5. Structures supporting energized conductors and live parts shall have sufficient strength to withstand the loads imposed on the structure by equipment and weather loadings. O. Reg. 22/04, s. 4 (6).

(7) In this section,

"weather loadings" means loads due to temperature, ice or wind acting on conductors and structures. O. Reg. 22/04, s. 4 (7).

When safety standards met

5. (1) Electrical installations operating at 750 volts or below that are not a direct part of a distribution system that meet the requirements set out in Rules 2-100 to 86-402 of the ESC are deemed to meet the safety standards set out in subsections 4 (2) and (3). O. Reg. 22/04, s. 5 (1).

(2) Overhead distribution lines that meet the requirements of CSA Standard C22.3 No. 1-01 Overhead Systems or the requirements set out in Rules 2-100 to 2-404 of section 2 and in sections 3, 4, 10, 12, 14, 18, 26, 28, 36, 75, 80 and 84 of the ESC are deemed to meet the safety standards set out in subsections 4 (2) and (4). O. Reg. 22/04, s. 5 (2).

(3) Underground distribution lines that meet the requirements of CSA Standard C22.3 No. 7-94 Underground Systems (Reaffirmed 1999) or the requirements set out in Rules 2-100 to 2-404 of section 2 and in sections 3, 4, 10, 12, 14, 18, 26, 28, 36, 75, 80 and 84 of the ESC are deemed to meet the safety standards set out in subsections 4 (2) and (5). O. Reg. 22/04, s. 5 (3).

(4) Distribution stations that meet the requirements set out in Rules 2-100 to 2-404 of section 2 and in sections 3, 4, 10, 12, 14, 18, 26, 28, 36, 75, 80 and 84 of the ESC or that meet the requirements of National Electrical Safety Code C2-1997 are deemed to meet the safety standards set out in subsections 4 (2) and (6). O. Reg. 22/04, s. 5 (4).

Approval of electrical equipment

6. (1) Electrical equipment that is part of a distribution system is approved if,

(a) its design and construction meet any of the standards for approval of equipment set out in Rule 2-024 of the ESC; or

(b) its design and construction comply with a code or standard under a rule of the distributor that provides an assurance of safety of the equipment that is the equivalent of the assurance of safety provided by the standards referenced in clause (a). O. Reg. 22/04, s. 6 (1).

(2) For the purpose of establishing whether electrical equipment is approved under clause (1) (b), the equipment shall be tested and inspected in accordance with testing and inspection procedures that are adequate for that purpose. O. Reg. 22/04, s. 6 (2).

Approval of plans, drawings and specifications for installation work

7. (1) Before beginning work on an electrical installation that is or may form part of a distribution system, a distributor shall ensure that the installation work is based,

(a) on plans that have been prepared by a professional engineer and that the plans have been reviewed and approved in accordance with subsections (2) to (7); or

(b) on the distributor's standard design drawings or standard design specifications that have been assembled by a professional engineer, by an engineering technologist certified by the Ontario Association of Certified Engineering Technicians and Technologists or by another competent person and that those standard drawings and specifications have been reviewed and approved in accordance with subsections (2) to (7). O. Reg. 22/04, s. 7 (1); O. Reg. 272/04, s. 2.

(2) Review and approval of plans, standard design drawings and standard design specifications under this section shall be carried out,

(a) by a professional engineer, who may or may not be the professional engineer who prepared the plans or assembled the standard design drawings or standard design specifications; or

(b) by the Authority at the request of the distributor. O. Reg. 22/04, s. 7 (2).

(3) Where, after reviewing the plans, standard design drawings or standard design specifications under clause (2) (a), a professional engineer is satisfied that the safety standards set out in section 4 are met, he or she shall prepare a certificate and provide it to the distributor. O. Reg. 22/04, s. 7 (3).

(4) A certificate under subsection (3) constitutes approval of the plans, standard design drawings or standard design specifications. O. Reg. 22/04, s. 7 (4).

(5) Where, after reviewing the plans, standard design drawings or standard design specifications under clause (2) (b), the Authority is satisfied that the safety standards set out in section 4 are met, it shall approve them and provide a certificate of approval to the distributor. O. Reg. 22/04, s. 7 (5).

(6) The plans, standard design drawings or standard design specifications, along with the certificate, shall be kept by the distributor and made available to the Authority upon request. O. Reg. 22/04, s. 7 (6).

(7) This section does not apply with respect to work on an electrical installation that involves the replacement of one piece of electrical equipment with another piece of electrical equipment of the same voltage and characteristics. O. Reg. 22/04, s. 7 (7).

Inspection and approval of construction

8. (1) Before putting a distribution system into use, a distributor shall ensure that the construction of the system has been inspected and approved in accordance with this section. O. Reg. 22/04, s. 8 (1).

(2) An inspection under this section shall be carried out,

(a) by a professional engineer on behalf of the distributor;

(b) by qualified persons identified in a construction verification program developed by the distributor and approved by the Authority; or

(c) by the Authority at the request of the distributor. O. Reg. 22/04, s. 8 (2).

(3) A professional engineer who carries out an inspection under clause (2) (a) shall prepare a record of the inspection. O. Reg. 22/04, s. 8 (3).

(4) Where the professional engineer is satisfied on the inspection that the safety standards set out in section 4 are met, he or she shall prepare a certificate to that effect and provide it, along with the record of inspection, to the distributor. O. Reg. 22/04, s. 8 (4).

(5) A person who carries out an inspection under clause (2) (b) shall inspect the system in accordance with the methods and techniques described in the approved construction verification program referred to in that clause and prepare a record of the inspection. O. Reg. 22/04, s. 8 (5).

(6) Where the person carrying out the inspection under clause (2) (b) is satisfied on the inspection that the safety standards set out in section 4 are met, he or she shall prepare a certificate to that effect and provide it, along with the record of inspection, to the distributor. O. Reg. 22/04, s. 8 (6).

(7) A distributor who obtains a certificate pursuant to an inspection under clause (2) (a) or (b) shall keep the certificate and record of inspection and make them available to the Authority on request. O. Reg. 22/04, s. 8 (7).

(8) Where the Authority is satisfied on an inspection carried out under clause (2) (c) that the safety standards set out in section 4 are met, the Authority shall prepare a certificate to that effect and provide it, along with the record of inspection, to the distributor. O. Reg. 22/04, s. 8 (8).

(9) A certificate under subsection (4), (6) or (8) constitutes approval that the system may be put into use. O. Reg. 22/04, s. 8 (9).

Deviations from required standards

9. (1) Where a distributor upgrades the distribution lines of a distribution system such that the system does not meet the standards for clearances and separations in respect of distribution lines referred to in subsection 5 (2) or (3), the distributor may still put the system into use if a professional engineer certifies that,

(a) the reason for failing to meet the standards was a lack of space; and

(b) the failure to meet the standards will not materially affect the safety of any person or property. O. Reg. 22/04, s. 9 (1).

(2) If a distributor replaces a part or portion of an existing distribution system with a part or portion that is similar to the part or portion being replaced but that part or portion does not meet the safety standards set out in section 4, the distributor may put the system into use as long as no undue hazard to the safety of any person is created by doing so. O. Reg. 22/04, s. 9 (2).

Proximity to distribution lines

10. (1) Despite section 4 of CSA Standard C22.3, No. 1-01 Overhead Systems, a person may place an object closer to an energized conductor forming part of a system of overhead distribution lines than the required minimum separations from energized conductors forming part of such a system if the person first obtains an authorization from the distributor responsible for the energized conductor. O. Reg. 22/04, s. 10 (1).

(2) Despite sections 4 and 5 of CSA Standard C22.3, No. 7-94 Underground Systems (Reaffirmed 1999), a person may place an object closer to an energized conductor forming part of a system of underground distribution lines than the required minimum separations from energized conductors forming part of such system if the person first obtains an authorization from the distributor responsible for the energized conductor. O. Reg. 22/04, s. 10 (2).

(3) Before digging, boring, trenching, grading, excavating or breaking ground with tools, mechanical equipment or explosives, a contractor, owner or occupant of land, buildings or premises shall, in the interests of safety, ascertain from the distributor responsible for the distribution of electricity to the land, building or premises the location of any underground distribution line that may be interfered with in the course of such activities. O. Reg. 22/04, s. 10 (3).

(4) The distributor shall provide reasonable information with respect to the location of its underground distribution lines and associated plant within a reasonable time. O. Reg. 22/04, s. 10 (4).

Disconnection of unused lines

11. (1) A distributor shall disconnect and ground distribution lines of 750 volts or more that have not been in use for a prolonged period of time. O. Reg. 22/04, s. 11 (1).

(2) Prior to disconnecting and grounding the lines, the distributor shall de-energize them. O. Reg. 22/04, s. 11 (2).

(3) A distributor is not required to comply with subsection (1) where the lines, although unused, act as back-up or emergency lines. O. Reg. 22/04, s. 11 (3).

(4) A distributor is not required to comply with subsection (1) where the distributor provides the Authority with a report from, and a certificate signed by, a professional engineer indicating that,

(a) disconnecting and grounding the lines is not practical in the circumstances; and

(b) no undue danger to the safety of any person will be caused if the lines are not disconnected and grounded. O. Reg. 22/04, s. 11 (4).

Condition of an approval: reporting of serious electrical incidents

12. (1) It is a condition of an approval issued to a distributor for the use of a distribution system that the distributor, or any contractor or operator acting on the distributor's behalf, report to the Authority any serious electrical incident of which they become aware within 48 hours after the occurrence. O. Reg. 22/04, s. 12 (1).

(2) Where a serious electrical incident has occurred, a distributor, contractor or operator shall not interfere with or disturb, except in the interests of safety, saving life, relieving human suffering, continuity of service or preservation of property, any wreckage, article or thing at the scene of the incident that is connected to it and, in no case, shall wreckage, an article or a thing be carried away or destroyed unless an inspector so permits. O. Reg. 22/04, s. 12 (2).

(3) Where a serious electrical incident involving workers only is reported to the Ministry of Labour as required under the *Occupational Health and Safety Act* and that the Ministry has taken control of the scene of the incident, subsections (1) and (2) do not apply. O. Reg. 22/04, s. 12 (3).

(4) In this section,

"critical injury" means an injury of a serious nature that,

(a) places life in jeopardy,

(b) produces unconsciousness,

(c) results in a substantial loss of blood,

(d) involves the fracture of a leg or arm but not a finger or toe,

(e) involves the amputation of a leg, arm, hand or foot but not a finger or toe,

(f) consists of burns to a major portion of the body, or

(g) causes the loss of sight in an eye;

"serious electrical incident" means,

(a) any electrical contact that caused death or critical injury to a person,

(b) any inadvertent contact with any part of a distribution system operating at 750 volts or above that caused or had the potential to cause death or critical injury to a person,

(c) any fire or explosion in any part of a distribution system operating at 750 volts or above that caused or had the potential to cause death or critical injury to a person, except a fire or explosion caused by lightning strike;

"worker" means a person who performs work or supplies services for monetary compensation but does not include an inmate of a correctional institution or like institution or facility who participates inside the institution or facility in a work project or rehabilitation program. O. Reg. 22/04, s. 12 (4); O. Reg. 272/04, s. 3.

Same: audit

13. (1) It is a condition of an approval issued to a distributor for the use of a distribution system that the distributor engage an auditor to audit on an annual basis the distributor's compliance with sections 4, 5, 6, 7 and 8 and to prepare an audit report. O. Reg. 22/04, s. 13 (1).

(2) To conduct the audit and prepare the audit report, the distributor shall engage an organization that is,

(a) accredited by the Standards Council of Canada to register quality management systems whose scope of accreditation includes engineering services, construction and electricity supply; or

(b) acceptable to the Authority. O. Reg. 22/04, s. 13 (2).

(3) The distributor shall provide the audit report to the Authority on request. O. Reg. 22/04, s. 13 (3).

Same: declaration of compliance

14. It is a condition of an approval issued to a distributor for the use of a distribution system that the distributor submit to the Authority an annual statement of compliance with sections 3, 9, 10, 11 and 12 signed by a professional engineer or an officer or director of the distributor. O. Reg. 22/04, s. 14.

Compliance

15. (1) A distributor that is notified by the Authority that the distributor is not in compliance with any or all provisions of this Regulation shall remedy the non-compliance within the time set out in the notice. O. Reg. 22/04, s. 15 (1).

(2) If a distributor fails to remedy non-compliance with section 6 as required under subsection (1), the distributor shall immediately apply to the Authority for approval of equipment in accordance with Rule 2-024 of the ESC and the distributor may not use any other means available to obtain the approval. O. Reg. 22/04, s. 15 (2).

(3) If a distributor fails to remedy non-compliance with section 7 as required under subsection (1), the distributor shall obtain approval of plans, standard design drawings and standard design specifications by the Authority under clause 7 (2) (b) and subsection 7 (5) and the distributor may not use any other means available to obtain the approval. O. Reg. 22/04, s. 15 (3).

(4) If a distributor fails to remedy non-compliance with section 8 as required under subsection (1), the distributor shall obtain inspection and approval of construction by the Authority under clause 8 (2) (c) and subsection 8 (8) and the distributor may not use any other means available to obtain the approval. O. Reg. 22/04, s. 15 (4).

16. Omitted (provides for coming into force of provisions of this Regulation). O. Reg. 22/04, s. 16.

Back to top

This is **EXHIBIT "F"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Electrical Safety Authority

Guideline for Third Party Attachments

Ontario Regulation 22/04

Electrical Distribution Safety

October 5, 2005

Legal Disclaimer.

This document contains GUIDELINES ONLY to assist members of the industry in interpreting Ontario Regulation 22/04 - Electrical Distribution Safety - made under subsection 113(1) of Part VIII of the Electricity Act, 1998. These guidelines do not have the force of law. Where there is a conflict between these guidelines and any legislation or regulation which may apply, the relevant law prevails.

Retention Periods stated in the guidelines set out the minimum period for which referenced documents are to be retained. Each *owner* needs to make its own assessment of the appropriate retention period for specific documents based on its assessment of risk factors and potential liability.

Table of Contents

Continued on next page

Appendices

1.0 General

1.1 Purpose of Guideline.

This Guideline has been prepared to provide guidance to distributors on how to comply with section 7 Approval of plans, drawings and specifications for installation work and section 8 Inspection and Approval of Construction of Ontario Regulation 22/04 Electrical Distribution Safety. Specifically this guideline addresses third party attachments to the distribution systems of licensed distributors.

This Guideline is to be read in conjunction with Regulation 22/04. As a condition to using its distribution systems, each distributor will need to engage an auditor on an annual basis to prepare an audit report and demonstrate compliance with sections 4, 5, 7 and 8 of the Regulation.

This Guideline along with the Regulation and other appropriate standards form the basis on which the ESA will assess the safety of the electrical distribution installations within the Province of Ontario.

1.2 Condition of Attachment.

All companies who wish to place *attachments* on an *owner's* pole should have an agreement that allows the "*attacher*" to request these same *attachments*.

1.3 Definitions

1.1.1 "**attacher**" means the party making or applying for permission to attach to the *owner's* support structure (such as a pole);

1.1.2 "**attachment**" means a single connection of the *attacher's* equipment to the *owner's* support structure that has a direct or indirect influence on the performance, appearance, and safety of the support structure or the *owner's* ability to access and maintain it. The *attacher* may have multiple attachments to a support structure (such as a pole);

1.1.3 "**Certificate**" means a certificate issued by a *professional engineer*, ESA or a *qualified person* identified in the *owner's* construction verification program, that the construction meets the safety standards set out in Section 4 of the *Regulation*;

1.1.4 **"certificate of approval"** means the certificate issued by a *professional engineer* or ESA confirming that a *plan* or *Standard Design* meets the safety standards set out in section 4 of the *Regulation* and provided to the *owner*;

1.1.5 **"construction verification"** means the inspection, approval and documentation of any new construction or repairs to *distribution systems* including replacements of part or portion of a *distribution system*, *like-for-like replacements*, and *legacy construction* replacement with respect to the safety standards set out in Section 4 of the *Regulation*;

1.1.6 "***competent person***" means a person who,

a) is qualified because of knowledge, training and experience,

(i) to perform specific work, or

(ii) to organize work and its performance,

b) has knowledge of any potential or actual danger to health or safety in the workplace in relation to the work, and

c) is familiar with section 113 of the Act and the regulations made under it, and with the Occupational Health and Safety Act and the regulations made under that Act, that apply to the work. O. Reg.22/04;

1.1.7 **"distribution system"** means a system for distributing electricity, and includes any structures, equipment or other things used by a *owner* for that purpose;

1.1.8 **"distributor"** means a person who owns or operates a *distribution system* in the service territory defined in the electricity distribution license issued by the Ontario Energy Board (OEB);

1.1.9 **"equipment" or "electrical equipment"** means any apparatus, device, material used for the distribution of electricity, including materials that are non-electric in origin *(refer to the Regulation for the complete definition of "electrical equipment"*(O.Reg.22/04);

1.1.10 **"Good Utility Practice"** means any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry in North America during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good practices, reliability, safety and expedition. Good utility practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in North America (DSC);

1.1.11 **"legacy construction"** means existing construction built in accordance with *Good Utility Practice*, that does not meet current *Standard Designs*;

1.1.12 **"like-for-like replacement"** means the replacement of one piece of *electrical equipment* (one assembly) under all conditions, or a part or portion of a line under emergency conditions, on an existing *distribution system* that maintains as a minimum the characteristics and functionalities of the original installation;

1.1.13 **"no undue hazard"** for the purpose of *construction verification* of an electrical installation where indicated in this Guideline means that:

- metal parts that are not intended to be energized and that are accessible to unauthorized persons are adequately grounded,
- live parts are adequately insulated or barriered,
- the installation meets the minimum CSA clearances from buildings, signs and ground or barriers are installed to protect,
- the structure has adequate strength

where adequate means in accordance with *Good Utility Practice*;

1.1.14 **"owner"** means a licensed *distributor* that owns the support structure;

1.1.15 **"plan"** means the drawings and instructions that are prepared for the construction of new or modified *distribution system* that have been reviewed and approved by a *professional engineer* or ESA;

1.1.16 **"professional engineer"** means a person who holds a license or temporary license under the Professional Engineers Act (Reg. 22/04);

1.1.17 **"qualified person"** means a person identified in a *construction verification* program developed by the *owner* and approved by ESA for the purpose of inspection and approval of construction;

1.1.18 **"record of inspection"** means a record prepared by a *professional engineer*, ESA, or a *qualified person* identified in the *owner's construction verification* program, detailing the inspection of a constructed or repaired portion of an electrical *distribution system* with respect to the safety standards set out in section 4 of the *Regulation*;

1.1.19 **"Regulation"** means the Ontario Regulation 22/04 – Electrical Distribution Safety;

1.1.20 "**Service Drop**" means a small light-weight single communication cable or wire between an *attacher's* plant and customer's residence or place of business. The cable or wire shall be affixed in span, to a pole or existing messenger, constructed per the *attacher's* engineered "service drop" standard. The *owner* should establish a maximum lateral load to the plant;

1.1.21 **"Standard Designs"** means the standards such as standard design drawings, standard design specifications, technical specifications, and construction standards that have been reviewed and approved by a *professional engineer* or ESA for use by an *owner* or *attacher* and that the *owner* or *attacher* has authorized for use on an ongoing basis for the construction, operation, and maintenance of its plant in relation to the *distribution system*;

1.1.22 **"work instruction"** means the assembly of *Standard Designs* into drawings and instructions prepared by a *competent person* in accordance with the *owner's* or *attacher's* job planning process used for the installation of the *attacher's* new or modified *equipment* on the *owner's* support.

2.0 Third Party Attachment Process.

2.1 What is required under section 7 of Regulation 22/04?

Starting February 11, 2005 under section 7 of the *Regulation*, before beginning work on a *distribution system*, or effecting repairs, alterations or extensions on an existing *distribution system* an *owner* shall ensure that installation work is based on *plans* prepared by a *professional engineer* and,

- a *plan* must be reviewed and approved by a *professional engineer* or ESA and a *certificate of approval* provided to the *owner*; or

- *a work instruction* must be based on *Standard Designs* that have been reviewed and approved by a *professional engineer* or ESA and for which *certificates of approval* have been provided to the *owner*.

After approval, the *Regulation* allows the *attacher* to utilize *Standard Designs* for work on *distribution systems* without further design approvals being required by a *professional engineer* or ESA. The *attacher* may prepare *work instructions* using its own approved *Standard Designs* in accordance with its job planning process.

2.2 Exemption of *Service Drops* from audit requirements.

The installation and removal of *Service Drops* are exempted from the audit requirements of section 7 and section 8 of the *Regulation*. *Service Drops* are not exempt from section 4,5,7 and 8 of the *Regulation* and as such, must meet CSA C22.3, No. 1-01 Overhead Systems or C22.3, No.7-94 Underground Systems (Reaffirmed 1999).

2.3 Like-for-Like Replacement.

Like-for-like replacement, line repair or replacement work of non-electrical equipment done under emergency conditions (i.e. trouble calls), or *owner* or *attacher* maintenance programs are exempted from the requirements of section 7 of the *Regulation.* However, such work is to be inspected by a *competent person* to confirm that it presents *no undue hazards.*

When a transfer of equipment is proposed by an *owner* or an *attacher* it shall be considered a *like-for-like replacement* and shall be subject to the process for completing *records of inspection* and statement of *no undue hazards* identified in the *owner's* Construction Verification Program.

2.4 Additional Guideline References to Third Party Attachment.

Further references to third party attachments can be found in the Technical Guideline for Section 7 (Design) clause 2 and the Technical Guideline for Section 8 (Construction Verification) clause 2.

2.5 Design Approval.

There are two basic approaches to approving designs for third party attachments:

2.5.1 *Owner* Developed

The first approach is based on *standard designs* developed and approved by the *owner*, which allows for third party attachments of predetermined construction types. The *attacher* will need to supply information to the *owner* to ascertain that the proposed attachment is in accordance with the approved *standard designs*. After review and approval by the *owner* the permission is granted to proceed with construction; or

2.5.2 Attacher Developed

The second approach is based on the *attacher* providing a *plan* or *work instruction* assembled by a *professional engineer*; by the *attacher's* engineering technologist certified by the Ontario Association of Certified Engineering Technicians and Technologists or by the *attacher's competent person,* from a *standard design* developed and approved by a *professional engineer,* to the *owner*. The *owner* will grant permission to proceed after a review of the design and the *attacher's Certificate of Approval.* The *attacher* shall satisfy the *owner* as to the qualifications of it's *competent person*. See Appendix A for examples of what information may be required to be provided to prepare the *plan* or *work* *instruction*. If both parties agree, different levels of information may be required and provided than identified in Appendix A.

2.5.3 Work instructions.

The *attacher* may provide the *owner* with *work instructions* prepared to the *owner's* or *attacher's* standard design specifications that have been assembled by a *professional engineer* or a *competent person* and accepted by the *owner*.

2.6 Application for Licensed Occupancy of Poles

Accompanying this engineered drawing or *work instruction* should be an Application for Licensed Occupancy of Poles form filled out accordingly. This requested application should include the details from Appendix A as required. This application may also have the pole markings that the *owner* has installed in the field for clarity for current and future records.

2.7 Inspection and approval of construction

2.7.1 Record of Inspection and a Certificate

Once the new plant has been installed or the modifications to an existing *attachment* have been completed, a *professional engineer or ESA or a qualified person* identified in the *owner's* Construction Verification Program *must prepare a record of inspection and a certificate.* The *owner* will keep completed *records of inspection* and *certificates.*

2.7.2 What is an acceptable *Record of Inspection*?

A *record of inspection* is to include sufficient description to identify the work and equipment inspected. A *record of inspection* can consist of an engineered *plan*, an as-built drawing, or a set of *work instructions* signed and dated by a *professional engineer* or ESA or a *qualified person*.

2.7.3 Field Visits

Initial contact is required prior to the commencement of work and field visits may be required from time to time. Both parties should agree if a joint field visit might be required.

2.7.4 What is required for the *Certificate*?

The *certificate* can be a separate document or it can be a stamp or signature added to the *record of inspection* and/or construction drawings. It should include the following information:

- name and signature of the inspecting *professional engineer,* ESA representative *or qualified person*;
- name of the *distributor* that owns the system (i.e. *owner*);
- confirmation that the construction meets the *plan*, *work instruction*, or *Standard Design*; and
- date of certification.

2.7.5 Who can be designated as *Qualified Persons* to inspect?

A *qualified person* may be an employee of the *attacher*, but they must be identified in the *owner's* approved Construction Verification Program. It is the responsibility of the *owner* to determine the qualifications necessary to designate the *attacher's* employees as qualified in the Construction Verification Program. Alternatively the *owner* may choose to complete all of the inspections.

2.7.6 Confirmation of compliance.

The *owner* is responsible for the safety of the *distribution system* and all work completed on it. If the *owner* has designated employees of an *attacher* as *qualified persons*, it should complete an annual confirmation review of the work inspected and certified by the *attacher*. Once a year, a sample (suggested rate 10% to 15%) of the new "Application for Licensed Occupancy of Pole" locations taken out that year, may be audited for compliance.

2.7.7 Documentation

The *owner* is to retain the *records of inspection* and *certificates* and make them available to the ESA upon request for a period of at least one year after the annual audit, following construction completion, for audit purposes.

Appendix A1 - Minimum Permit Drawing Requirements for Proposed *Attachments* on *Owner* Poles.

1 Basic Drawing Requirements (applies to all drawings)

a. Title block (name & address of *Attacher*, date, drawing/project number, drawing revision number, location of project)
b. Name & phone number of the Project Manager for the specific application
c. Language: English/French as appropriate
d. Scale or Dimensions (where applicable): Metric
e. Scale Size (where applicable): Larger than or equal to 1:1000 (e.g. 1:1000, 1: 500, 1: 250)
f. Legend of symbols
g. Certified standards that have been applied
h. The competent person who assembled the work instruction or the *Professional Engineer* who approved the plan/design

2 Project Specific Drawing Orientation Requirements

i. North Point
j. Key Map
k. Street names: clearly indicated
l. Sidewalks, driveways, curbs, trees, buildings, bridges, rivers, railroads, other utilities if they add clarity to specific issues
m. Lot lines and/or buildings, and house numbers in front of poles
n. Clearly indicated poles and their ownership
o. Horizontal offset measurements for proposed pole contact close construction to buildings, other non-Owner overhead systems (ex. traffic, street lighting, signs), and/or bridges.

3 Project Specific Drawing Requirements

Proposed *Attacher* Information

a. Which side of the pole and orientation to be contacted
b. Proposed Electrical bonding locations and method (eg. Ground rods)
c. Proposed Dips and/or risers (Cable dip/riser details)
d. Proposed Ducts, guards, and/or concrete work on poles for dips and/or risers
e. Proposed and existing (where available) *Attacher* anchoring including size, strength, tension, and location (Including height and lead data)
f. Make ready work anticipated by the *Attacher* with the *Owner's* poles or third party *attachments*
g. Proposed/existing pedestal locations along route outside of boundaries specified in the Joint Use Agreement
h. Railroad, major highway, & river crossing engineering details & associated profiles
i. Pole height contact detail (by drawing or table) indicating dimensions above grade for all other existing attachments such as other Telecommunications /

CATV contacts by name, streetlight contacts, approximate separation to lowest electrical contact (neutral, secondary, primary, transformers, unprotected electrical riser/dips, decorative banners) for both new and existing Support Strands.

4 Project Specific Drawing Telecom Requirements

Proposed *Attacher* Information

a. Proposed cable and Support Strands clearly indicated with heavier line style and attachment method (e.g. CSA Heavy or diameter or kN)
b. Proposed cable to be Over-lashed to existing Support Strand and indicate owner of that Support Strand (e.g. CSA Heavy or diameter or kN)
c. Proposed/existing support strand size, strength, and sag/tension with proposed/existing cables (profile drawing acceptable) (e.g. CSA Heavy or diameter or kN)
d. Proposed telecommunication attachments to the pole (e.g. amplifiers, power supplies, antenna, *Attacher* electrical wiring and protection, and wire routing on the pole.) (Including information such as design data)
e. Proposed in span features and equipment such as slack storage & splice can locations

Appendix A2 – Sample Telecomm Data for JUP submissions

Default Telecomm Data for JUP submissions

	Allstream	Bell	FibreTech	Rogers	Telus
Messenger					
diameter (inches)	0.375"	0.375"	0.249 inches	0.25 inches	
type/grade	galvanized / class A	galvanized / grade A	galvanized / 180 grade	galvanized	
# wire composition	7 wire	7 wire	7 strand	7 strand	
UTS (lbs)	12,000 lbs	12,000 lbs	6400 lbs	6650 lbs	
weight (lbs/ft)	.270 lb/ft		0.129lbs/ft	.121lbs/ft	
Mounting height (mtr or ft)	5.1m	5.3m			
Down Guy Steel					
diameter (inches)	0.375"	0.375"	0.249 inches	0.25 inches	
type/grade	galvanized / class A	galvanized / grade A	galvanized / 180 grade	galvanized	
# wire composition	7 wire	7 wire	7 strand	7 strand	
UTS (lbs)	12,000 lbs	12,000 lbs	6400 lbs	6650 lbs	
weight (lbs/ft)	.270 lb/ft		0.129lbs/ft	.121lbs/ft	
Anchor					
Type	8" expanding	20" single plate	8" single helix	150mm	
holding capacity (Soil Type 5)*	13,500 lbs	32,000 lbs	13,500 lbs	28913N	
lead length		determined in field by applicant			
exclusive / shared		determined in field by applicant			
Rod					
diameter (inches)	5/8"	1.0"	0.75 inches	20mm	
length (ft)	8 ft		7 ft	1700mm	
breaking strength (lbs)	12,000 lbs		16,000 lbs	28692N	
Bundle					
Weight		applicant to gather specifics on a submission by submission basis.			
Diameter		applicant to gather specifics on a submission by submission basis.			
CSA Heavy Tension (45m Ruling Span)		applicant to gather specifics on a submission by submission basis.			

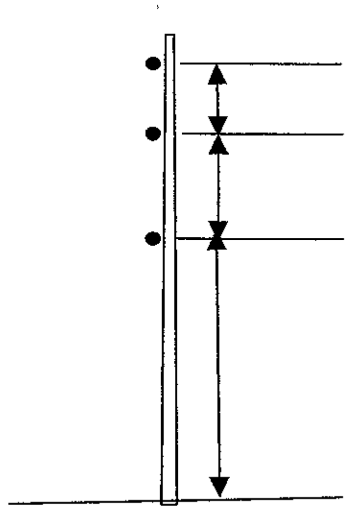
Net X Tangent Pole Profile

Bell

Orientation
Hydro Supply Space

Neutral Space

Communication Space



Pole Data	**No. / Location**	
	Plan #	
	Height	
	Class	
	Composition	
	Orientaton	
Communication Space		
	Strand	
	Sag/Tension	
	Bundle Size	

Notes:
Design

All project drawing(s) have been assembled utilizing existing Bell Canada Construction Standards, Specifications and Equipment which comply with the requirements of CSA C22.3 No.1 Overhead Systems and CSA-C83-96(R2000) Communication and Power Line Hardware. (Meets Section 7)

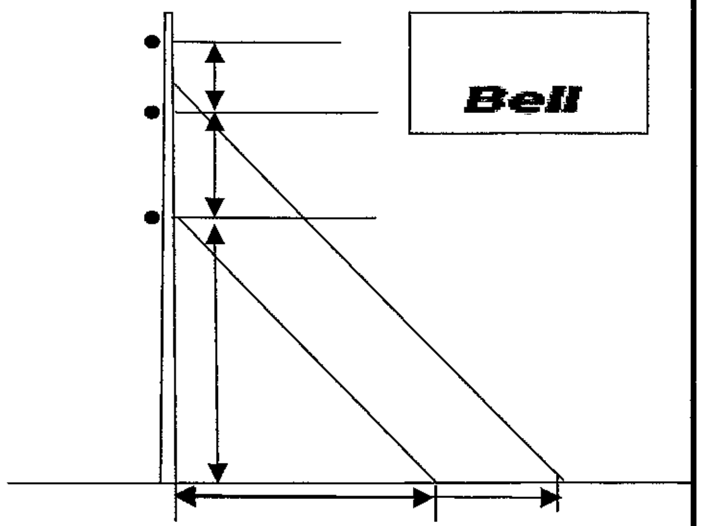
Net X Anc Guy Pole Profile

Orientation

Hydro Supply Space

Neutral Space

Communication Space



Down Guy Lead

Pole Data		
	No. / Location	
	Plan #	
	Height	
	Class	
	Composition	
	Orientaton	
	Pole Appilcation	

Communication Space								
	Structure	**Type**	**Size**	**Sag/Tension**	**Breaking**	**Sep./Lead**		
	Strand							
	Guy							
	Anchor							
	Bundle Size							

Notes:

Design

All project drawing(s) have been assembled utilizing existing Bell Canada Construction Standards, Specifications and Equipment which comply with the requirements of CSA C22.3 No.1 Overhead Systems and CSA-C83-96(R2000) Communication and Power Line Hardware. (Meets Section 7)

Pole Owner Logo Here

Record of Inspection
Third Party Attachment
Like for Like Construction

Date	
Reference	

Project Information:

Project	Project	Constructio Issued	Propose Complèon Date	Number Poles

Attacher Inspection Information:

Utility	Yes /No	Inspector' Name	Date Inspecte	Position	Signatur
Bell					
Roger' CAT					
TTC					
Hydro Teleco					
Viaco					
Allstea					
Enbridg					
City Traffic Signs					
City Traffic Signals					
City Street lighting					
Othe					

Sample only

Ontario Regulation 22/04

This site has been left in a condition that presents no undue hazard to the the Technical Guidelines ed by the ESA under Ontario Regulation

Please return original document upon

Appendix A4 – Sample Toronto Hydro Record Of Inspection for Third Party Attachment #2

<table>
<tr><th colspan="3">Record of Inspection Third Party Attachment</th></tr>
<tr><td colspan="2">AS CONSTRUCTED
☐ Aerial Installation
☐ U/G Installation
With changes shown on this Drawing</td><td>☐ North District
☐ South District
☐ East District
☐ West District</td></tr>
<tr><td rowspan="4">Attachment owner</td><td>Permit #</td><td>Date</td></tr>
<tr><td colspan="2">Print Name</td></tr>
<tr><td colspan="2">Position</td></tr>
<tr><td colspan="2">Signature</td></tr>
<tr><td colspan="3">☐ This is to certify that the construction as recorded in this drawing is consistent with the Approved Plan,Standard Designs, or work instruction.</td></tr>
</table>

Appendix A5 – Sample
Hydro One Application for Licensed Occupancy of Poles

hydro one

APPLICATION FOR LICENSED OCCUPANCY OF POLES

*Please complete all boxes above the dotted line.

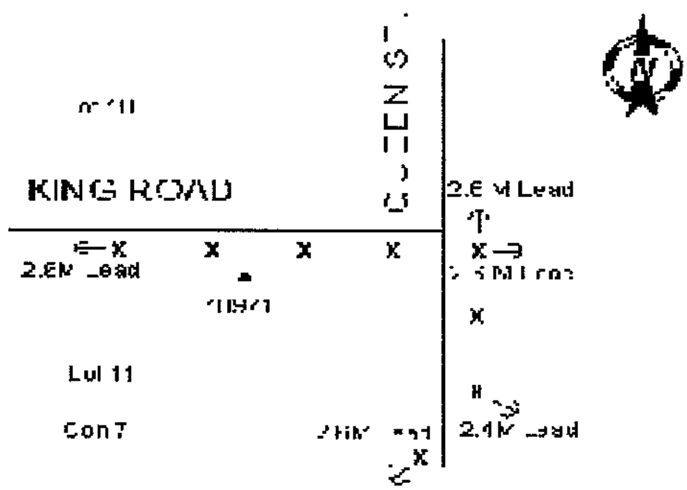
[illegible] Audit Date August, 2001	[illegible] [illegible]

[illegible]	[illegible]	title:
[illegible]	[illegible]	[illegible]
[illegible]		

[illegible] Line Tension- 21 kN,
[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
Lots 10 - 11	Con. 7	East Gwillimbury	York Region

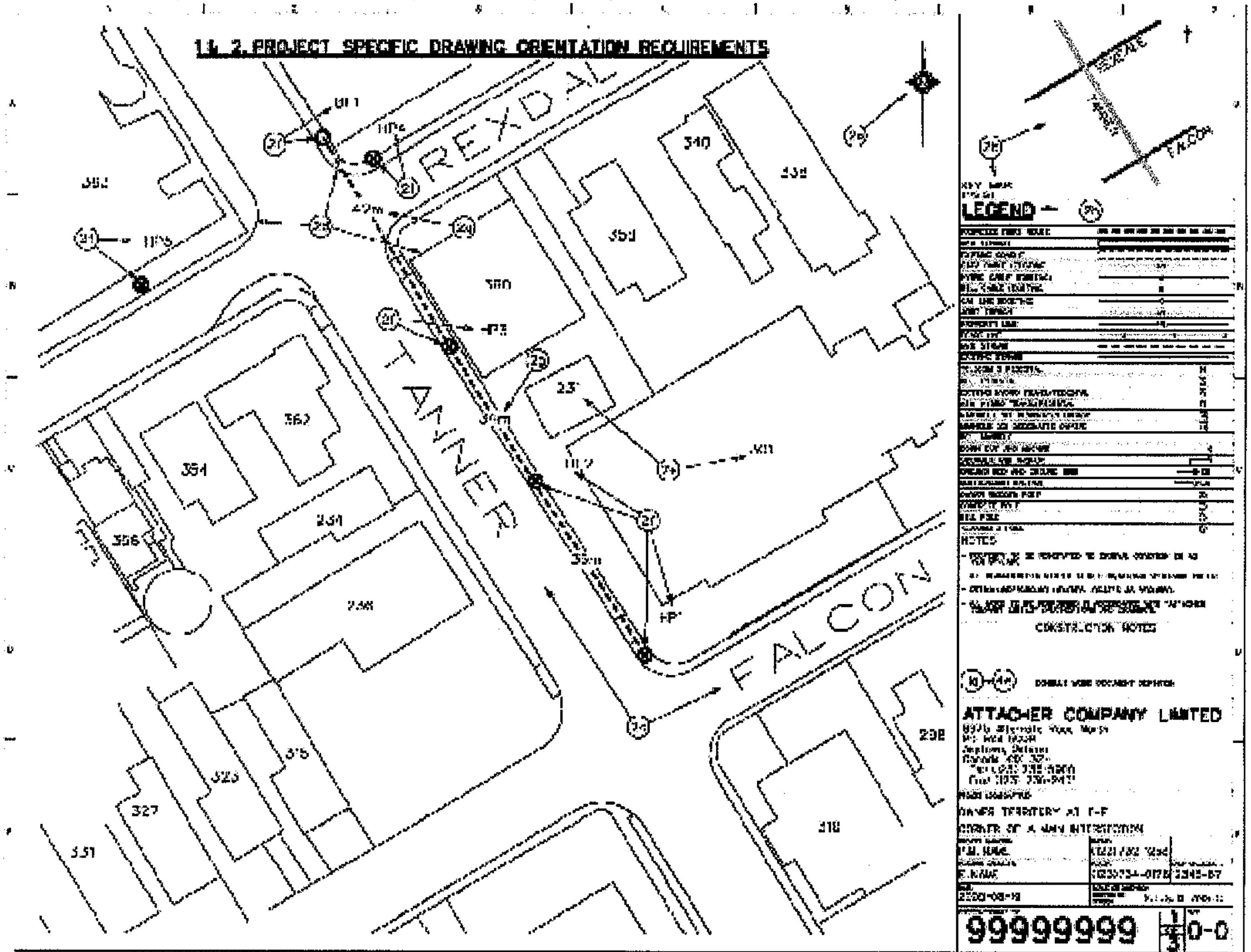


* [illegible]

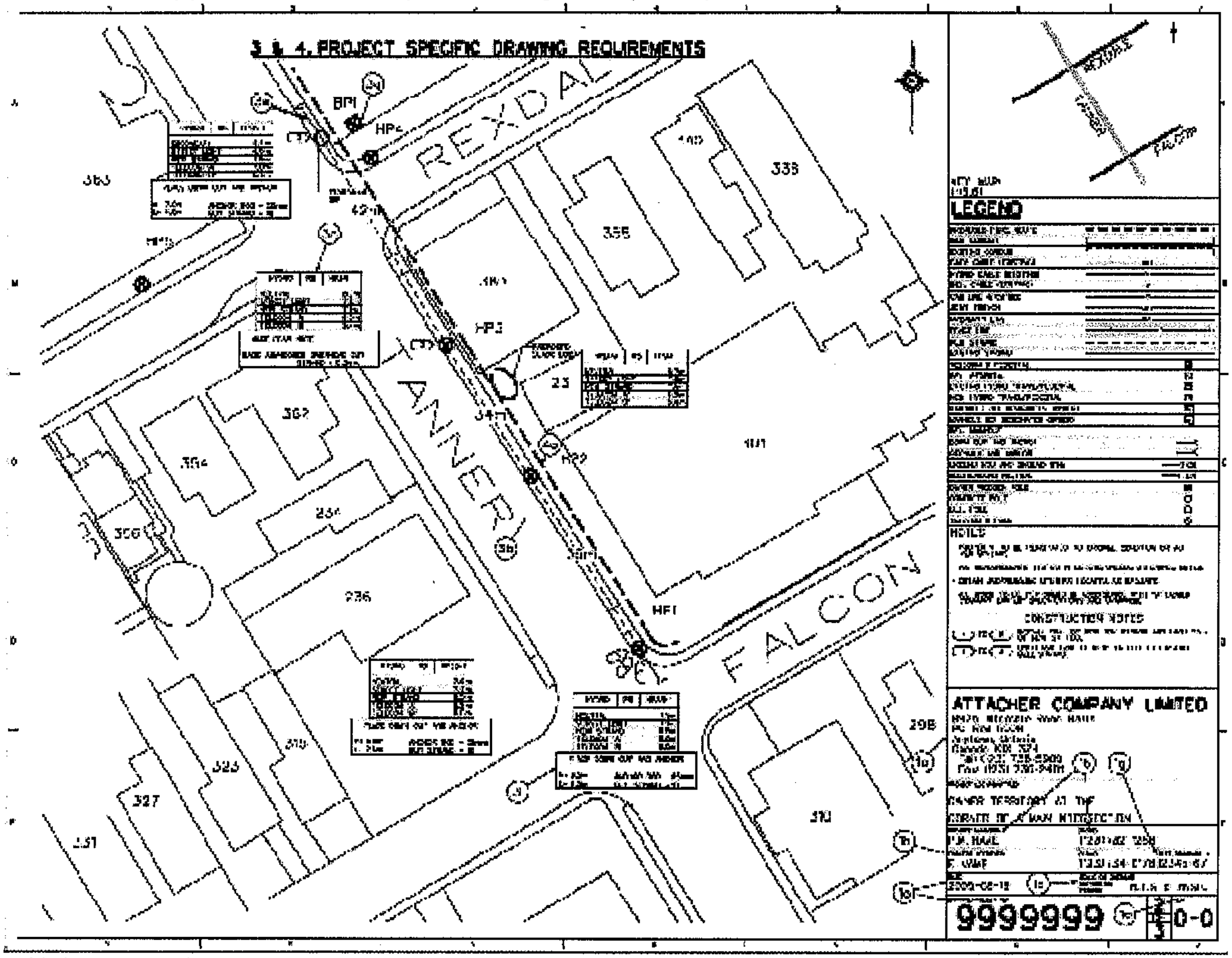
<u>For Internal Use Only</u>

[illegible]	[illegible] O = [illegible] X = Rental Pole	[illegible] 8
[illegible] Operations/ Front Line Manager		
[illegible] Newmarket	[illegible] [illegible]	
[illegible]	☑ yes ☐ no	
Date	[illegible]	

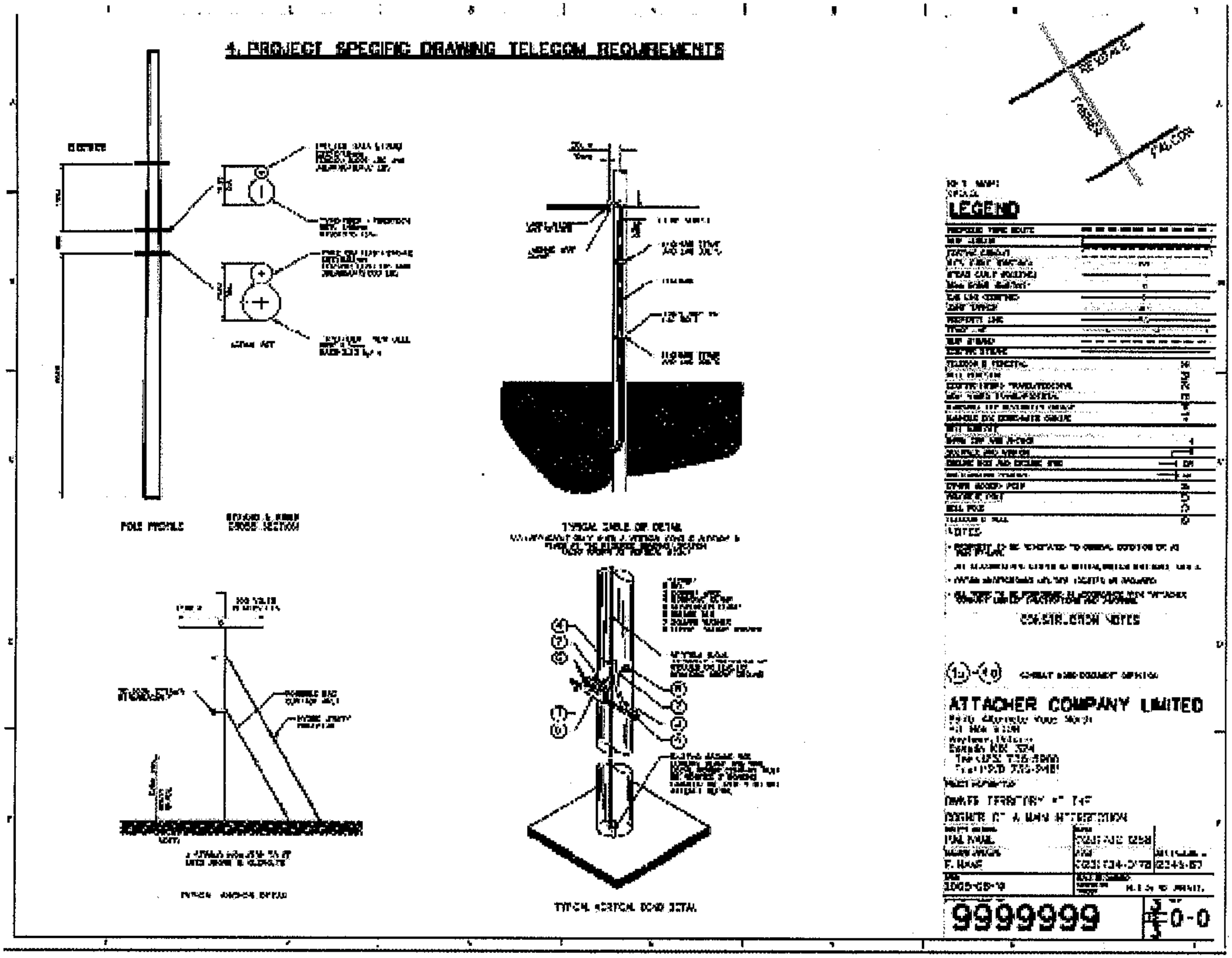
Appendix A6 – Sample of Project Specific Orientation Requirements



Appendix A6 – Sample Drawing - Project Specific Requirements



Appendix A6 – Sample Drawing - Telecom Requirements



This is **EXHIBIT "G"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

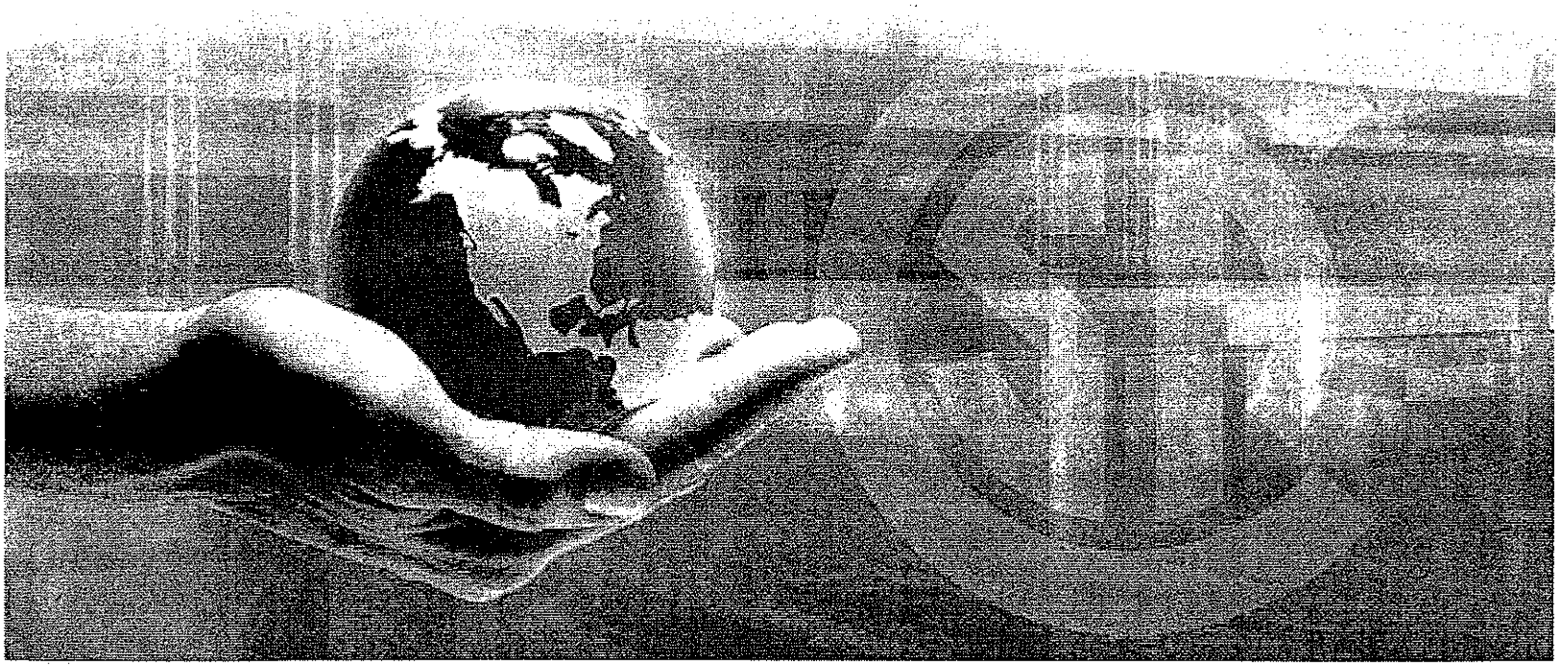
Amanda Klein

A Commissioner, etc. (Province of Ontario)

CANADIAN STANDARDS ASSOCIATION

C22.3 No. 1-10

Overhead systems



Legal Notice for Standards

Canadian Standards Association (CSA) standards are developed through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA is a private not-for-profit company that publishes voluntary standards and related documents. CSA has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA and the users of this document (whether it be in printed or electronic form), CSA is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA's and/or others' intellectual property and may give rise to a right in CSA and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:
- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to
- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

CANADIAN STANDARDS ASSOCIATION

CSA Standards Update Service

C22.3 No. 1-10
July 2010

Title: *Overhead systems*
Pagination: 160 pages (xi preliminary and 149 text), each dated **July 2010**

To register for e-mail notification about any updates to this publication

- go to **www.ShopCSA.ca**
- click on **E-mail Services** under **MY ACCOUNT**
- click on **CSA Standards Update Service**

The **List ID** that you will need to register for updates to this publication is **2420675**.

If you require assistance, please e-mail **techsupport@csa.ca** or call 416-747-2233.

Visit CSA's policy on privacy at **www.csagroup.org/legal** to find out how we protect your personal information.

CSA Standard

C22.3 No. 1-10

Overhead systems

CANADIAN STANDARDS ASSOCIATION

®Registered trade-mark of Canadian Standards Association

Published in July 2010 by Canadian Standards Association
A not-for-profit private sector organization
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6
1-800-463-6727 • 416-747-4044

100%

The Canadian Standards Association (CSA) prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

To purchase CSA Standards and related publications, visit CSA's Online Store at **www.ShopCSA.ca** or call toll-free 1-800-463-6727 or 416-747-4044.

ISBN 978-1-55491-422-7
Technical Editor: John O'Neill

Contents

Annexes

Tables

Figures

Technical Committee on Overhead Systems

E.H. Wiebe	Manitoba Hydro, Winnipeg, Manitoba	*Chair*
E. Alfonso	TELUS, Burnaby, British Columbia	
J.M. Asselin	Alcan Cable Division, Alcan Inc., Mississauga, Ontario	
M. Bell	Hydro One Networks Inc., Toronto, Ontario	
M. Byrne	Toronto Hydro Electric System, Toronto, Ontario	
J.C. Carrière	Hydro-Québec, Montréal, Québec	
S. Cumminger	Bell Aliant, Halifax, Nova Scotia	
R. Desbiens	Hydro-Québec Distribution, Montréal, Québec	
M. Ereth	SaskPower Corporation, Regina, Saskatchewan	
T. Gardiner	Newfoundland and Labrador Hydro, St. John's, Newfoundland and Labrador	*Associate*
C. Gartner	SaskTel, Regina, Saskatchewan	
E. Ghannoum	Outremont, Québec	
G.F. Girda	Canadian Pacific Railway, Calgary, Alberta	
I. Hathout	Hydro One Networks Inc., Toronto, Ontario	
M.F. Ishac	SNC-Lavalin, Calgary, Alberta	
M. Jaffer	ENMAX Power Corp., Calgary, Alberta	*Associate*
K. Jansa	Canadian Electricity Association (CEA), Ottawa, Ontario	*Associate*
C. Kafel	Enersource Hydro Mississauga, Mississauga, Ontario	*Associate*

Z.J. Kieloch	Manitoba Hydro, Winnipeg, Manitoba	
P. Krotky	Automated Solutions International Inc., Cambridge, Ontario	
B. Lacoursière	RS Technologies, a Division of Resin Systems Inc., Calgary, Alberta	
J.A. McFadgen	Nova Scotia Power Inc., Halifax, Nova Scotia	
R.J. Morris	Environment Canada, Toronto, Ontario	
T. O'Hara	NB Power Corporation, Fredericton, New Brunswick	*Associate*
C.I. Orde	Utilitech Consulting Inc., Nanton, Alberta	*Associate*
R. Renwick	AltaLink Management Ltd., Calgary, Alberta	*Associate*
J. Robertson	Electrical Safety Authority (ESA), Mississauga, Ontario	
R. Rugge	BC Hydro, Burnaby, British Columbia	
T. Shmyr	EPCOR Distribution & Transmission Inc., Edmonton, Alberta	
G. Smith	Newfoundland Power Inc., St. John's, Newfoundland and Labrador	
R. Stevenson	C.H.R.S. Associates, Oakville, Ontario	
J. Toth	British Columbia Transmission Corporation, Vancouver, British Columbia	*Associate*
T.L. Troke	Newfoundland Power Inc., St. John's, Newfoundland and Labrador	
S. Turcot	Bell Canada, Montréal, Québec	
R. Williams	Hydro Ottawa Limited, Ottawa, Ontario	*Associate*
A. Zolotoochin	BC Hydro, Burnaby, British Columbia	*Associate*
J.K. O'Neill	Canadian Standards Association, Mississauga, Ontario	*Project Manager*

Preface

This is the ninth edition of CSA C22.3 No. 1, *Overhead systems*, one of a series of Standards issued under the *Canadian Electrical Code, Part III*. It supersedes the previous editions, published in 2006, 2001, 1987, 1985, 1979, 1976, and 1970, and the original edition, which was published as a series of five Standards in 1959, 1953, 1947, and 1940.

Significant changes in this edition include

(a) modification of grounding requirements;
(b) revised requirements for crossings of railways;
(c) moving information about load factors related to linear analysis of wood poles to an Annex;
(d) updated criteria for clearance over navigable water;
(e) updated practices for conductor tensioning; and
(f) general updating of the Standard.

This edition of CSA C22.3 No. 1 covers both the linear and non-linear design methods for wood pole structures, with non-linear design being the preferred method. Non-linear design was first recognized as the preferred method in this Standard in a 2003 amendment to the 2001 edition. In the future, the non-linear method will be the sole method; the linear design method is retained in this edition of the Standard to facilitate the transition.

The reliability-based design of transmission lines is covered by CSA C22.3 No. 60826.

The purpose of the annexes is to provide the background information and reasoning necessary for the application of this Standard. It is not the intent of the annexes to modify the requirements of any of the clauses in this Standard.

CSA acknowledges the generous support of the Canadian Electricity Association (CEA) in the development of this Standard.

This Standard was prepared by the Technical Committee on Overhead Systems, under the jurisdiction of the Strategic Steering Committee on Power Engineering and Electromagnetic Compatibility, and has been formally approved by the Technical Committee. This Standard will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

July 2010

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*

Requests for interpretation should

(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
(b) provide an explanation of circumstances surrounding the actual field condition; and
(c) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update, *which is available on the CSA Web site at www.csa.ca.*

C22.3 No. 1-10
Overhead systems

1 Scope

1.1
This Standard applies to electric supply and communication lines and equipment located entirely outside of buildings and fenced supply stations.

1.2
Existing installations (including maintenance replacements, additions, and alterations) meeting the original designs that currently comply with prior editions of this Standard, need not be modified to comply with this edition of the Standard, except as might be required for safety reasons by the authority having jurisdiction.

1.3
This Standard, which forms part of the *Canadian Electrical Code, Part III*, provides requirements for the construction of overhead systems. It covers electric supply and communication circuits that
(a) are installed alone;
(b) are in joint use;
(c) are in proximity to each other or other facilities;
(d) cross each other or other facilities; and
(e) cross railways, highways, navigable waterways, or land that is likely to be traversed by vehicles or pedestrians.

1.4
This Standard presents a choice between deterministic and reliability-based design methods. Reliability-based design methods are covered by CSA C22.3 No. 60826.

1.5
The requirements contained in this Standard do not constitute complete design and construction specifications, but rather prescribe the minimum design requirements that are most important to the
(a) safety of persons;
(b) continuity of service; and
(c) protection of property.

1.6
Conditions not covered by this Standard are governed by equivalent Standards in common use or by the authority having jurisdiction.

1.7
In some cases in this Standard, specific types of construction are envisaged. This does not preclude the use of other types of construction, provided that the engineering representatives involved can demonstrate the safety and suitability of these alternatives.

1.8
The use of terms such as "where practicable" is not intended to provide an opportunity for not meeting the requirements of this Standard, but indicates the preferred clearance or method. Where an alternative is

not specified, the engineering solution that most closely adheres to the preferred method should be used. Where the requirements of more than one clause apply, all should be satisfied.

1.9

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (nonmandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

CAN/CSA-A14-07
Concrete poles

B149.2-10
Propane Storage And Handling Code

C22.1-09
Canadian Electrical Code, Part I

C22.2
Canadian Electrical Code, Part II

C22.2 No. 41-07
Grounding and bonding equipment

C22.3
Canadian Electrical Code, Part III

CAN/CSA-C22.3 No. 3-98 (R2007)
Electrical coordination

C22.3 No. 5.1-93 (R2007)
Recommended practices for electrical protection — Electric contact between overhead supply and communication lines

C22.3 No. 60826-06*
Design criteria for overhead transmission lines
**A new edition is currently under development and will supersede the 2006 edition.*

C57-98 (R2006)
Electric power connectors for use in overhead line conductors

C411.1-10
AC suspension insulators

CAN/CSA-C411.4-98 (R2008)*
Composite suspension insulators for transmission applications
**A new edition is currently under development and will supersede the 1998 edition.*

C411.5-10
Dead-end/suspension composite insulators for overhead lines ≤ 75kV

C411.6 (under development)
Line post composite insulators for overhead distribution lines

C411.7 (under development)
Composite insulator for guy wires

CAN/CSA-C61089-03 (R2008)
Round wire concentric lay overhead electrical stranded conductors

CAN/CSA-G12-92 (R2007)
Zinc-coated steel wire strand

CAN/CSA-O15-05 (2009)
Wood utility poles and reinforcing stubs

Z98-07
Passenger ropeways and passenger conveyors

ANSI (American National Standards Institute)
C29.1-1988 (R2002)
American National Standard — Test Methods for Electrical Power Insulators

C29.11-1989 (R1996)
American National Standard for Composite Suspension Insulators for Overhead Transmission Lines — Tests

C29.12-1997 (R2002)
American National Standard for Insulators — Composite — Suspension Type

C29.13-2000
American National Standard for Insulators — Composite — Distribution Deadend Type

ASCE (American Society of Civil Engineers)
Manual 104-2003
Recommended Practice for Fiber-Reinforced Polymer Products For Overhead Utility Line Structures

Manual 111-2006
Reliability-Based Design of Utility Pole Structures

ASTM International (American Society for Testing and Materials)
D1036-99 (2005)
Standard Test Methods of Static Tests of Wood Poles

CIGRE (International Council on Large Electric Systems)
Technical Brochure 273 (2005)
Overhead conductor safe design tension with respect to Aeolian vibrations

Health Canada
Safety Code 6 (2009)
Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz

IEC (International Electrotechnical Commission)
IEC/TS 60815-1 (2008)
Selection and dimensioning of high-voltage insulators intended for use in polluted conditions — Part 1: Definitions, information and general principles

IEC/TS 60815-2 (2008)
Selection and dimensioning of high-voltage insulators intended for use in polluted conditions — Part 2: Ceramic and glass insulators for a.c. systems

IEC/TS 60815-3 (2008)
Selection and dimensioning of high-voltage insulators intended for use in polluted conditions — Part 3: Polymer insulators for a.c. systems

IEEE (Institute of Electrical and Electronics Engineers)
80-2000
IEEE Guide for Safety in AC Substation Grounding

487-2007
IEEE Recommended Practice for the Protection of Wire-Line Communication Facilities Serving Electric Supply Locations

ANSI/IEEE 738-2006
IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors

ANSI/IEEE C2-2007
National Electrical Safety Code

C95.6–2002
IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz

National Research Council Canada
National Building Code of Canada, 2005

NERC (North American Electric Reliability Corporation)
Standard FAC-003-1 (2006)
Transmission Vegetation Management Program

Transport Canada
Canadian Aviation Regulations 2009-1,
Part VI — General Operating and Flight Rules,
Standard 621.19 — Standards Obstruction Markings

TP 1247
Land Use in the Vicinity of Airports — Part I — Obstacle Limitation Surfaces

Navigable Waters Protection Act, R.S.C. 1985, c. N-22

Minor Works And Waters (Navigable Waters Protection Act) Order, April 22, 2009 (Canada Gazette, Vol. 143, No. 19 — May 9, 2009)

Other publication

Deno, D.W., and L.E. Zaffanella. 1982. Field Effects of Overhead Transmission Lines and Stations. In *Transmission Line Reference Book*, 3rd ed., Palo Alto: Electric Power Research Institute

3 Definitions and abbreviations

3.1 Definitions

The following definitions shall apply in this Standard:

Across or **cross** — crossing over or under.

Active electrical equipment — equipment used in primary metering, transformer, regulator, capacitor, and recloser installations.

All-dielectric self-supporting (ADSS) fibre optic cable — a communication cable consisting of coated glass optical fibres contained in a protective dielectric fibre optic unit that is surrounded by, or attached to, suitable dielectric strength members and jackets.

Note: *The dielectric properties of the outermost jacket can be of a class that is*

(a) *suitable only for application in electric fields where the level of electrical stress on the jacket does not exceed* 12 kV *space potential; or*

(b) *suitable for application in electric fields where the level of electrical stress on the jacket can exceed* 12 kV *space potential.*

Caution: *Some cables are manufactured with semiconducting jackets appropriate for either Items (a) or (b).*

Alongside or **along** — within the boundaries of the area under consideration or within a specified distance from it.

Ballast — crushed stone or gravel placed between and below the ties of railway tracks.

Bonding — the electrical interconnecting of metallic parts or conductors in order to maintain them at the same potential and achieve a desired distribution of currents within a grounding system.

Cable — an assembly of one or more insulated electrical or optical conductors, or a combination thereof, in a compact form, enclosed in a covering consisting of a combination of metal, plastic, or other materials used to provide mechanical and electrical protection.

Catenary parameter (C = H/w) — the horizontal tension (H) in a conductor (expressed in N) divided by the conductor unit weight (w) (expressed in N/m).

Circuit — a conductor or system of conductors through which electric current or optical energy is intended to flow.

Civil infrastructure — structures, trenches, and components used to support, enclose, and/or protect lines, cables, and equipment.

Clearance — the distance, under specified design conditions, between the nearest points of two objects at points where at least one object is movable.

Note: *See also* ***Separation*** *and* ***Spacing****.*

Climbing space — the space reserved on a structure that permits line workers to have access to equipment and conductors located on the structure and that allows equipment to be hoisted to its desired position.

Coefficient of variation (COV) — the standard deviation of a sample divided by its mean.

Common-structure crossing — a crossing of lines wherein a structure acts as a common support to, and forms an integral part of, each line at the point of crossing.

Communication cable — a cable used for a signal or communication service.

Communication circuit — a circuit used for a signal or communication service.

Communication conductor — a conductor in a communication circuit or cable.

Communication line — see **Line**.

Conductor — a material used for the transmission of electrical, electromagnetic, or optical energy.

Coordinated electrical protection — (as applied to supply and communication lines in close physical proximity) — the protective measures applied to the plant of both utilities so that
(a) the supply and communication lines are designed, constructed, operated, and maintained in such a way that the supply voltage is promptly removed from the communication plant (including lines) by de-energization or other means, both initially and following subsequent breaker operations, in the event of contact between the supply line and the communication plant (including lines); and
(b) in the event that the communication plant comes into contact with the supply conductors, the voltage and current impressed on the communication plant (including lines) do not exceed the safe operating limit of the communication protective devices.

Creep — the permanent elongation of suspended wire due to the effects of tension over a period of time.

Cross — see **Across**.

Crossarm assembly — an assembly that consists of crossarms and the devices used to attach them to a structure.

Dead-end assembly — the component parts, such as clamps or devices, that secure the conductors to the structure in dead-end construction.

Dead-end construction — the attachment to structures of wires or cables so as to transmit their tensions directly to the structures in one direction only.

Deterministic design — a line design in which the load, strength, and load factors are specified and not necessarily related to statistical data.

Distribution line — a supply line that is used primarily for supplying electrical energy to local area circuits and services.

Drop — the portion of a communication circuit that runs from the line to the premises served.

Effectively grounded — permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that can result in undue hazard to connected equipment or to persons.

Fastening — a tie, clamp, or other device used to secure wire or cable attachments to a structure.

Final unloaded tension — the tension in the conductor when in the condition of final unloaded sag.

Full-tension compression splice — a device that is applied to a conductor in order to join together two separate ends of conductor that are of the same size and characteristics.
Notes:
(1) *A full-tension compression splice is installed through the application of pressure; compressive energy may be supplied through the use of*
   (a) mechanical press and suitable dies;
   (b) explosive devices; or
   (c) other means as might be developed in the future.
(2) *A properly applied full-tension compression splice will have a tensile strength equal to or greater than 95% of the ultimate tensile strength of the conductor. See Mechanical Duty Class 1 in CSA C57.*

Grounded — electrically connected to earth through a grounding electrode or through an extended conducting body.

Grounded conductor — a line conductor that is grounded at one or more points.

Grounding — the provision of a permanent and continuous conductive path to the earth that
(a) has sufficient ampacity to carry any fault current liable to be imposed on it;
(b) has a sufficiently low impedance to limit the voltage rise above ground potential; and
(c) facilitates the operation of the protective devices in the circuit.

Grounding conductor — a conductor used to connect a grounding electrode directly to the device, component, or system that is being grounded.

Grounding conductor carried in aerial spans — a conductor carried in one or more spans that is used to interconnect equipment needing a common ground to an adequate grounding electrode.
Note: *Grounding conductors carried in aerial spans do not include supply-line neutral conductors or lightning protection wires.*

Grounding electrode — a metallic conductor, rod, or other object, or an assembly of objects, that is embedded in or suitably connected to the earth.
Note: *Grounding electrodes are used for maintaining ground potential on associated grounding conductors and dissipating current into the earth.*

Grounding system — an interconnected system of grounding electrodes, grounding conductors, and bonding conductors that is designed to provide an acceptable connection between an electrical system or component and the earth.

Group of similar conductors — conductors that
(a) occupy the same crossarm;
(b) form part of a single circuit; or
(c) are otherwise considered to function as a unit having common structural behaviour.

Guarded — protected by mechanical means of a strength adequate to inhibit contact by the public or damage by the public or workers to a structure, attachment, wire, or conductor.

Guy —

Span guy — a guy that spans the distance between structures.

Working guy — a guy installed for the purpose of supporting a structure under normal working loads.

Guy assembly — the strand, insulators, clamps, anchor rods, anchors, and devices used to secure the guy to the structure.

Guy strand — a wire or strand whose main function is to provide mechanical support to a structure.

Highway — a road to and from which access is permitted only at designated entrances and exits.

Ice drop-off — a condition that can occur with ice-loaded conductors in mild weather, where the ice coating drops off suddenly and causes a conductor to rise to a level significantly higher than the normal stationary level.

Inaccessible — see **Isolated**.

Initial unloaded tension — the tension in a conductor when the conductor is in the condition of initial unloaded sag.

In-span crossing (as applied to two lines) — a crossing without use of a common structure.

Insulated — separated from other conducting surfaces by a dielectric material or air space that offers a high resistance to the passage of current and to disruptive discharge through the material or air space.

Inverted level arrangement — the relative vertical positions of circuits or lines that cross or are attached to the same structure such that
(a) communication facilities are above one or more of the supply lines or circuits; or
(b) lower-voltage circuits are above higher-voltage circuits.
Note: *See **Normal level arrangement**.*

Isolated — not readily accessible to persons unless special means for access are used.

Jacket — a protective non-metallic covering that is applied to cables with or without sheaths.

Joint use — the supporting or enclosing of supply and communication lines within or on a common civil infrastructure.

Lateral conductor — a conductor that extends in a generally horizontal direction at an angle to the general direction of the line conductors.

Lightning protection wire — a grounded overhead wire used for lightning protection.
Note: *Lightning protection wires are usually located at or near the top of the supporting structure.*

Limited- or controlled-access highway — a fully controlled highway to which access is controlled by a governmental authority for purposes of improving traffic flow and safety.
Note: *Limited-access highways have no grade crossings and have carefully designed access connections.*

Line — conductors and cables, including their associated equipment and supporting structures, that are located entirely outside of buildings.

Communication line — a line used for a signal or communication service.

Supply line — a line used for transmitting a supply of electrical energy.

Linear analysis — a structural analysis method that does not consider P-delta (secondary moment) effects of structure displacements.

Line conductor — a wire that is used to carry electric current and is supported by structures for one or more spans.

Live — electrically connected to a source of potential difference or electrically charged to have a potential that is significantly different from that of the surrounding earth.
Note: *In this Standard, the term "live" is sometimes used in place of "current-carrying" or "energized".*

Load —

Assumed load —
(a) for supports, taps, and splices — the force resulting from the assumed conductor load and other applicable forces, multiplied by the applicable load factor specified in this Standard; and
(b) for wires and cable attachments — the force in the wire or cable attachment resulting from the applicable weather load.

Thermal load — the heating effect produced in a wire or conductor by which its temperature is raised above the ambient due to
(a) the absorption of heat from the sun; and
(b) the heat produced by the current flowing in the conductor.

Weather loads — loads that result from low temperature, ice, and/or wind acting on conductors and structures.

Load effects — loads acting jointly or separately.
Note: *Load effects can be axial forces, shear forces, bending moments, or a combination of the three.*

Load factor — the factor by which a load is multiplied to create an assumed load.
Note: *A load factor takes into account uncertainties in loading conditions and, in the case of deterministic designs, the strength of materials.*

Loading — see **Load.**

Luminaire — a complete lighting unit consisting of a light source and its direct appurtenances, such as globes, reflectors, housings, and those supports integral to housings.
Note: *Luminaires do not include brackets that are separate units.*

Main line — the supply or communication line involved when strength requirements are being considered for a specific crossing, proximity, or joint-use section that calls for the strongest grade of construction.

Maximum planned summer operating current — the maximum rms current that an individual conductor of a circuit is designed to carry under specified summer maximum ambient conditions.
Note: *The maximum planned summer operating current does not include the current under fault conditions or short-duration emergency conditions.*

Mean (μ) — the arithmetic sum of a sample of data divided by the number of units (observations) in the sample.

Messenger — a wire or strand for supply or communication lines that supports, in addition to its own weight, the weight of one or more conductors or cables.
Notes:
(1) *The messenger does not form part of the electrical circuit.*
(2) *See also* ***Supporting conductor.***

Minimum (as applied to a value in this Standard) — all deviations are positive.
Note: *For example, a minimum value of 1 means 1.0000 ..... or greater.*

Multi-grounded neutral — a supply-line neutral conductor that is grounded at multiple locations so that the neutral is effectively grounded.

Near — in such proximity as to increase the possibility of interference.

Neutral conductor — a metallic conductor that forms a continuous return path from source to load for a supply line.
Note: *Neutral conductors are generally grounded.*

Non-energized supply plant — supply plant equipment or parts that are not intended to be connected directly to a source of voltage but that could become energized accidentally.
Note: *Non-energized supply plant includes through-bolts, braces, and transformer and other supply equipment cases.*

Non-linear analysis — a structural analysis method that considers geometric non-linearities and P-delta (secondary moment) effects of structure displacements.

Normal level arrangement — the relative vertical positions of lines that cross or are attached to the same structure, as follows (reading from the uppermost position downwards):
(a) supply (higher voltages);
(b) supply (lower voltages);
(c) communication; and
(d) trolley contact conductors and associated feeders.

Normally inaccessible — not readily accessible to persons unless special means for access are used.

Open (as applied to conductors) — bare or uninsulated.

Optical groundwire (OPGW) — a grounded overhead wire consisting of optical fibres integrally constructed into stranded metallic wires.

Ordinary high-water mark (OHWM) — the limit or edge of the bed of a body of water.
Note: *In the survey industry, the line of vegetation along a body of water is used to identify the OHWM. In the case of non-tidal waters, the OHWM is sometimes known as the "bank" or "limit of the bank".*

Overcurrent protection — the devices applied to a circuit and arranged to disconnect the protected circuit or equipment when the current exceeds a predetermined value for a predetermined length of time.

Overhang — the longitudinal suspension of one or more of the conductors on a line over a route normally traversed by vehicles.

P-delta effect — the additional bending moment applied to a vertical pole by a vertical load, P, multiplied by the horizontal deflection, delta (δ), at its point of application, as measured from the vertical axis of the pole.

Pipeline — a line of piping, generally of circular cross-section, for the transmission of gases, liquids, or solids outside of buildings.
Notes:
(1) *Pipelines include all associated branches, extensions, tanks, reservoirs, pumps, racks, compressors, loading facilities, and other outside works.*
(2) *A pipeline does not include pipe-type electric power cables.*

Proximity — the relative location of lines such that the failure of a conductor or any part of the structure (such as overturning at the ground line) interferes with the normal use, operation, or maintenance of public or private property, plant, or other facilities, through contact or encroachment on minimum clearance requirements by the conductor or structure.

Qualified person — a person who is familiar with the construction and operation of an apparatus and with the hazards involved, and who is authorized by the applicable utility to perform certain functions in connection with the plant under consideration.

Railway — the track(s) and control facilities of any transportation system operating on a fixed rail or track.

Rated ampacity — the current that results in a temperature rise in a bare conductor of 60 °C above an ambient of 40 °C and, for a covered conductor, a rise of 40 °C above an ambient of 40 °C, with the following parameters:
(a) a wind velocity of 0.61 m/s;
(b) an emissivity of 0.5;
(c) full sunshine;
(d) a solar absorption coefficient of 0.5; and
(e) an elevation at sea level.

Readily accessible — able to be reached, entered, or influenced without difficulty, obstruction, or the use of special means.

Reliability-based design — a line design in accordance with CSA C22.3 No. 60826.

Right-of-way — a strip of land reserved for public roads, railway tracks, pipelines, supply or communication lines, or other services.

Riser — a cable, grounding, or neutral conductor that rises or descends to interconnect an overhead system and an underground system.

rms — the root mean square value of an alternating current or voltage.

Sag (as applied to a conductor at any point in the span) — the vertical distance from a particular point on a conductor to a straight line between its two points of support.

Final unloaded sag — the sag of a conductor after
(a) it has been subjected to a load equivalent to that prescribed for the loading district in which it is situated and subjected to the effects of creep; and
(b) the load has been removed.

Initial unloaded sag — the sag of a conductor prior to the first application of an external load or prior to the effects of creep.

Maximum sag (as applied to any point of a wire or conductor) — the larger of the following:
(a) the sag under the thermal loading conditions specified in this Standard; or
(b) the sag under a vertical load that is equivalent in magnitude to the total resultant loading calculated from the ice, wind, and temperature conditions specified in this Standard for the loading district in which the line is located.

Unloaded sag (as applied to a conductor) — the sag of a conductor in the absence of an external load and at a specified conductor temperature.

Self-supporting cable — a cable that has a messenger integrated into its construction that is suitable for supporting the cable.

Separation — the distance between the nearest points of two objects, where both objects are fixed.
Note: *See also* ***Clearance*** *and* ***Spacing.***

Service conductor — a conductor that forms part of a circuit used for delivering electrical energy at 750 V or less from the secondary distribution line or distribution feeder, or from the transformer, to the wiring systems of a premises.

Spacing — the distance between the centres of two objects where both objects are fixed.
Note: *See also* ***Clearance*** *and* ***Separation.***

Span guy — see **Guy**.

Span wire — a wire or strand between two structures whose main function is to supply mechanical support to trolley conductors, luminaires, and similar equipment.

Standard deviation (σ) — the positive square root of the variance of a sample of data.

Strand — one or more uninsulated wires whose main function is to provide mechanical support.

Structure — the main supporting unit for a supply line and/or communication line.
Note: *A structure can be*
(a) a pole made of wood, concrete, fibre-reinforced composite, or metal;
(b) a lattice steel tower; or
(c) a cable suspension system.

Supply cable — a cable in a supply line.

Supply circuit — a circuit used for transmitting an electrical energy supply.

Supply conductor — a conductor in a supply line.

Supply line — see **Line.**

Support — a pole, tower, foundation, guy, crossarm, pin, insulator, fastening, or other component used to support wire or cable attachments.

Supporting conductor — a conductor whose purpose is to support other conductors.

Supporting strand — see **Messenger.**

Supporting structure — a structure and its supports.

Suspension strand — see **Messenger.**

Swing — the horizontal displacement (resulting from any loads specified in this Standard) of any point on a conductor from its position at rest.
Note: *Swing includes the deflection of insulators that are free to swing.*

Tension change — when wire or cable attachments have different tensions on each side of a structure.
Note: *Tension change is usually accomplished by means of dead-end construction.*

Termination — the termination of wire or cable attachments on a structure.
Note: *Termination is usually accomplished by means of dead-end construction.*

Transmission line — a supply line used for transmitting bulk electrical energy between power stations, switching stations, or substations.

Variance — the sum of the squares of the deviations of the data points from the mean value of the sample, n, divided by $(n - 1)$.

Vertical conductor — a conductor extending in an approximately vertical direction on a pole or structure.

Voltage — rms voltage-to-ground, unless otherwise specified.
Notes:
(1) *The voltage of a grounded circuit is the highest effective voltage between any conductor of a circuit and the point or conductor of the circuit that is grounded, unless otherwise specified.*
(2) *The voltage of an ungrounded circuit is the highest effective voltage between any two conductors of the circuit, unless otherwise specified.*

Wet flashover voltage — the voltage at which the air surrounding a clean wet insulator or shell completely breaks down, determined in accordance with ANSI C29.1 and the applicable insulator standard.

Wire and cable attachments — conductors, messengers, cables, guys, and any wires and hardware attached to line supports.

Working guy — see **Guy.**

Working space — the space reserved at the side of a structure that
(a) permits line workers to have access to equipment and conductors located on the structure; and
(b) allows for the installation of equipment.

Zone of influence — the area around a power station (or any ground electrode carrying any return portion of a ground fault current) that is raised in potential with respect to remote ground.

3.2 Abbreviations

AASC — aluminum alloy stranded conductor
ACSR — aluminum conductor, steel reinforced
ADSS — all-dielectric self-supporting
ASC — aluminum stranded conductor
COV — coefficient of variation
OHWM — ordinary high-water mark
OPGW — optical groundwire
UTS — ultimate tensile strength
Note: *UTS is also known as rated tensile strength (RTS).*

4 General requirements

4.1 General design and maintenance

4.1.1 Multiple requirements
Where two or more requirements apply to a situation, the requirement specifying the greater clearance, separation, spacing, or strength shall take precedence.

4.1.2 Service and operating conditions
All electric supply and communication lines and equipment shall be of suitable design and construction for the service and conditions under which they are to be operated.

4.1.3 Accessibility

4.1.3.1 Normal access
Parts of lines or equipment that need to be examined, adjusted, or maintained during operation shall be arranged so as to be readily accessible to qualified persons by the provision of adequate climbing and working spaces, as well as by the various other clearances and separations specified in this Standard. All structures shall be kept free of unauthorized attachments that could be hazardous and obstruct or otherwise hamper the operations of the utilities using the structures.

4.1.3.2 Access by hydraulic lift
At the time that a structure is designed, the means of access for maintenance shall be determined, and necessary space and facilities shall be provided for access by means of a hydraulic boom truck, lift, or equivalent.

4.1.3.3 Access by helicopter
On higher-voltage lines, the need for accessing structures and conductors by helicopter shall be considered. Where necessary, special landing surfaces shall be provided, taking into account all safe clearances to surrounding growth. Where necessary, provisions shall be made for access to the centre phase in a flat-configuration structure and to conductors immediately adjacent to ground wires.

4.1.4 Climbing space

4.1.4.1
Where climbing space is required in accordance with Clause 4.1.3.1, it shall be free from obstructions and shall provide sufficient space, adjacent to the structure, to de-energized conductors or to adequately protected and/or insulated conductors, in order to allow safe access to circuits, equipment, and other attachments on the upper part of the structure. Except as specified in Clauses 4.1.4.2 and 4.1.4.3, the climbing space shall be not less than 0.75 m × 0.75 m adjacent to any conductors, cables, crossarms, or other attachments of the party using any lower part of the structure, and shall extend at least 1 m above and 1 m below the limiting attachments. The climbing space at the various levels of the structure shall be so arranged that transformers, crossarms, and other equipment can be hoisted to the upper position of the structure.

4.1.4.2
Where climbing space is needed adjacent to energized circuits that are not protected or insulated, sufficient additional space shall be provided to allow for climbing safety.

Note: *Though this requirement also applies to normal level arrangements, it is particularly important in inverted level arrangements, where the circuits on the lower part of the structure generally need greater allowances of space than if the circuits were located in the "upper" or "normal" position.*

4.1.4.3
Where a pole carries only communication circuits, or where only supply service conductors are attached to the top of a common crossing pole, the climbing space through a communication line shall be not less than 0.40 m × 0.75 m.

4.1.5 Working space
Working space shall be provided on the climbing face of the structure and shall have the same horizontal dimensions as the climbing space. The height of the working space shall be not less than that required by this Standard for the vertical separation of line conductors carried at different levels on the same structure, except that along crossarms the working space shall extend to the outermost pin position of the crossarms.

4.1.6 Obstruction in climbing space or working space
Attachments on the structure shall not encroach on the climbing space or working space, with the exception of
(a) pole steps at the side of the climbing space or working space on non-wooden poles, or crossarms along the side of the working space or climbing space;
(b) longitudinal communication runs along the side of the working space or climbing space, provided that their vertical arrangement does not obstruct climbing of the structure;
(c) longitudinal runs of supply conductors of 0 to 750 V on racks, supply cables of 0 to 750 V on messengers, or supply cables of 0 to 750 V having effectively grounded continuous metal sheaths, along the side of the climbing space; and
(d) risers or vertical runs in the working space or climbing space that are suitably protected and do not interfere with the use of climbing equipment.

4.1.7 Tree pruning
Where trees are located near supply-line conductors, they shall be pruned, where practicable, to maintain the flashover distance specified in Table 35. This distance shall be applied in accordance with the conditions specified in Clause 5.2. Other field conditions can warrant consideration of an additional buffer. Where pruning is impracticable, the conductors shall be protected as necessary to prevent damage and electrical hazards.

Notes:
(1) *For supply lines operating at 200 kV or higher, refer also to NERC Standard FAC-003-1.*
(2) *Where trees are located near conductors or messengers on joint-use lines, they should be pruned where practicable, such that under normal operating conditions, there is no load-bearing contact between the conductors or messengers and the trees.*

4.2 Structures and attachments

4.2.1 Protection against fires
Structures shall be located, guarded, and maintained such that exposure to brush, grass, rubbish, or building fires is minimized.

4.2.2 Protection against mechanical damage
Where structures are exposed to hazards where the resulting damage would substantially affect their strength, they shall be protected by suitable guards.

4.2.3 Insulation of energized conductors attached to structures
Bare and covered energized conductors attached to steel, wood, concrete, or fibre-reinforced composite structures shall be insulated in accordance with Clause 8.18. Insulators are not required for multi-grounded neutrals or grounding conductors.

4.2.4 Risers

4.2.4.1 Separation between risers of communication and supply systems

If it is necessary to install risers for communication systems and risers for supply systems on the same pole, they shall be placed on different quadrants of the pole and grouped such that they do not interfere with the use of climbing equipment. On structures other than poles, the separation between risers of communication and supply systems shall be great enough to permit maintenance of each plant without interference. When located on streets or roadways, risers shall be placed such that the risk of damage by traffic is minimized.

Note: *Placing risers for communication systems and supply systems on the same pole should be avoided where practicable.*

4.2.4.2 Mechanical protection of supply cables

Riser cables of supply systems shall be protected by a covering that provides suitable mechanical protection for the full length of the run, starting at least 0.3 m below the surface of the earth.

Supply riser cables that have a grounded metal sheath or concentric neutral need not have further protective covering above the 2.5 m level for non-joint-use poles. On poles jointly used with communication systems, the protective covering shall extend at least 1 m above the communication plant.

4.2.4.3 Mechanical protection of communication cables and conductors

Although communication riser cables and conductors need not have mechanical protection for considerations of safety, adequate protection shall be provided to prevent damage or service interruptions.

4.2.5 Protection against climbing

4.2.5.1 Playgrounds and schoolyards

Structures located on or adjacent to playgrounds or schoolyards and carrying open conductors of supply or communication lines shall be constructed, located, or guarded so as to prevent climbing by anyone other than qualified persons.

4.2.5.2 Other locations

Structures that can be climbed without the use of special means and that carry supply-line conductors that exceed 750 V shall be protected by fences or other means against climbing, or shall carry signs in the predominant languages of the locality that warn against trespassing and call attention to the hazards. Bridge fixtures supporting such conductors shall also be guarded and marked. Unguarded poles carrying conductors that exceed 750 V shall not have permanent steps that are located less than 3 m above the ground or surface and that provide access to the pole.

4.2.6 Protection against corrosion

4.2.6.1

All metal supporting structures and hardware subject to corrosion, including bolts, nuts, washers, guys, guy rods, and similar items, shall be protected by galvanized coating, paint, or other treatments that effectively retard corrosion, in accordance with the appropriate CSA Standard for such items. Alternatively, these items shall be manufactured from materials that are corrosion resistant or shall be reinforced with additional material such that minimum strength requirements specified in Clause 8 or in CSA C22.3 No. 60826 are met until the item is replaced.

Metallic components shall be

(a) compatible with one another in order to minimize galvanic corrosion; or

(b) provided with appropriate cathodic protection.

4.2.6.2

Where gas or oil pipelines are located in the vicinity of supply or communication lines, they shall be assessed to determine whether the cathodic protection on the pipelines will cause corrosion to towers, guys, and other buried equipment and, where necessary, mitigating measures shall be implemented. For wood pole lines where insulators are installed in the guys, this assessment might not be necessary.

4.2.7 Grounding and insulating of guys

4.2.7.1 General

Guys located such that the failure of the guys or nearby supply conductors could result in contact with supply conductors shall be effectively grounded or insulated. Where a guy is connected to an effectively grounded metallic structure or ground connection on a wood or fibre-reinforced composite pole, an insulator is not required. Where gas or oil pipelines are involved, an assessment should be performed in accordance with Clause 4.2.6.2.

Where insulators are used or are necessary to prevent electrochemical corrosion of anchor rods or hazards from grounded guys in the supply space, the requirements of Clauses 4.2.7.2 and 4.2.7.3 shall be met.

4.2.7.2 Electrical strength of guy insulators

Guy insulators shall have a dry flashover voltage rating of at least double the voltage-to-ground of the highest-voltage supply circuit with which the guy could come in contact and a wet flashover voltage rating equal to the highest voltage between any two conductors. Two or more insulators may be used in series to comply with this requirement.

4.2.7.3 Use of guy insulators

Where a guy could fail and come in contact with the supply conductors of the structure to which it is attached, only one insulator location shall be required.

Where the guy could come in contact with the supply conductors of a separate supply line, two insulator locations shall be placed so as to include the exposed section of the guy between them.

The guy insulator(s) shall be located so that, in the event of a guy failure, the location of the insulator(s) will not be less than 2.5 m above the ground or accessible surface.

4.2.8 Marking of guys

Except for guys in areas where cross-country, vehicular, or pedestrian traffic is not expected, all guys shall be marked in a substantial and conspicuous manner. If there is more than one guy at the same anchor, a guy marker shall be applied on both the innermost and outermost down-guy.

4.2.9 Luminaires, luminaire span, and supply wires

4.2.9.1

Luminaire span or supply wires shall be provided with insulation suitable for the applicable voltage and type of service.

4.2.9.2

Current-carrying metal parts of a luminaire (except lamp leads) shall be adequately insulated from non-current-carrying metal parts.

4.2.9.3

Strain insulators having a dry flashover voltage rating of at least double the voltage-to-ground of the circuit and a wet flashover voltage rating equal to the highest voltage between any two conductors shall be inserted in the span wires supporting luminaires. Such insulators shall be located not less than 1.8 m from the structure.

4.2.9.4
Where luminaires are wired internally, the conductors used shall be provided with insulation for the applicable voltage, temperature, and type of service.

4.2.10 Traffic lights
Traffic lights and associated brackets shall satisfy the requirements for luminaires specified in this Standard.

4.2.11 Trolley span wires and brackets
A strain insulator shall be inserted in each trolley span wire and, in the case of trolley brackets, an insulator shall be placed on each side of the trolley contact conductor support. These insulators shall have a wet flashover voltage rating of at least twice the voltage of the trolley circuit. Such insulators shall be placed not less than 1.8 m from the structure.

Where trolley feeders are to be attached to a structure below communication attachments, the trolley feeders shall be placed on a crossarm.

4.3 Overhead conductors

4.3.1 Identification
Conductors, cables, and equivalent longitudinal strands of supply and communication lines shall be installed in such a manner as to facilitate identification by qualified persons. This may be achieved by one or more means, including
(a) occupation of definite relative levels throughout the line;
(b) attachment of distinctive insulators or crossarms;
(c) consistent standards of construction; and
(d) marking or numbering.

4.3.2 Common neutral
Primary and secondary supply-line neutrals may use a single conductor as a common neutral, provided that such a conductor meets the requirements of a multi-grounded neutral.

4.3.3 All-dielectric self-supporting (ADSS) fibre optic cables
An all-dielectric self-supporting fibre optic cable is normally considered a communication cable with respect to separations and clearances. Reduced separations and clearances may be considered where the issues of ADSS cable jacket dielectric strength, worker qualifications, and public safety have been addressed in accordance with Clause 1.7.

4.3.4 Optical groundwire (OPGW)
An OPGW, where installed as a supply transmission-line lightning protection wire, shall be considered a part of the supply system with respect to clearance, separation, loading, and strength requirements. Special electrical protection measures can be warranted when the OPGW is routed from the supply system space to a communication space or other space.

4.4 Coordinated electrical protection
Where supply and communication lines are located in sufficiently close proximity that electrical contacts are possible, electrical protection shall be applied in accordance with CSA C22.3 No. 5.1. Where electrical protection is not possible, stronger grades of construction shall apply (see Clause 6).

4.5 Inductive coordination

4.5.1 Supply and communication circuits
Supply and communication circuits and their connected apparatus shall be designed, constructed, operated, and maintained with due regard to avoiding or minimizing interference to the service provided

by the communication circuits and hazards to persons using, operating, or maintaining the communication circuits. Where excessive inductive interference or induced voltages are anticipated or experienced, the methods of coordination specified in CAN/CSA-C22.3 No. 3 shall be applied.

4.5.2 Other wire facilities

If other wire facilities exist where supply parallels are proposed (e.g., those associated with ski tows or aerial tramways), an assessment shall be performed to determine and address the possible hazards of electrostatic or electromagnetic induction.

4.6 Special rules for communication lines

4.6.1 Communication lines (including supply circuits used exclusively for the operation of communication circuits)

4.6.1.1

Lines shall have grades of construction and clearances in accordance with the requirements for communication lines as specified in this Standard, provided that they meet the voltage and power requirements specified in Clause 4.6.1.2 or the conditions specified in Clause 4.6.1.3. Otherwise, they shall meet the requirements specified for supply lines of the applicable voltage.

In the case of interconnection of communication lines that are owned by separate utilities, all parties shall conform to the requirements of this Standard concerning voltage and power limitations.

Note: *Communication lines include those for telephone, telegraph, railway signal, messenger call, clock, fire, police alarm, community antenna, and other systems.*

4.6.1.2

Where open wire or non-metallic sheathed cable is used, the communication circuits or supply circuits used exclusively for the operation of communication circuits shall operate at voltages not exceeding 150 V line-to-ground or 300 V between any two points of the circuit, and the transmitted power shall not exceed 150 W under normal operating conditions or fault conditions.

4.6.1.3

Where metallic sheathed cable is used, the voltage and power limitations specified in Clause 4.6.1.2 shall not apply, provided that

(a) the metallic sheath is continuous and effectively grounded;
(b) the metallic sheath is capable of carrying, without damage, the maximum current that could develop from a fault within the cable;
(c) supply circuits in such cables are promptly de-energized in the case of a cable fault;
(d) supply circuits in such cables are terminated at points accessible only to qualified persons;
(e) communication circuits brought out of such cables and not terminating at points only accessible to qualified persons are protected and arranged such that, in the event of failure within the cable, the voltage on these circuits does not exceed 300 V line-to-ground and is promptly removed; and
(f) all circuits in such cables or sections of cable are operated by one party and are accessible only to qualified persons.

4.6.1.4

Communication cable messengers shall be effectively grounded to protect customers in the case of accidental contact between supply conductors and communication facilities. The metal sheaths or shields of cables shall be bonded to the messenger to avoid voltage differences due to lightning surges or supply contacts.

The communication messenger shall be electrically continuous throughout the length of the facility. Where there are several communication messengers on the same pole line, they shall be bonded together.

Lateral messengers shall be bonded to the main cable route messenger. When a communication drop facility has a messenger or supporting conductor, it shall be bonded to the messenger on the main communication facility.

The thermal rating of the messenger and bonding shall be sufficient to withstand induced circulating currents and the induced currents under short-circuit conditions.

4.6.2 Communication circuits used exclusively in the operation of supply lines

4.6.2.1 General

Communication circuits used exclusively in the operation of supply lines may be run as ordinary communication circuits or supply circuits under the conditions specified in Clauses 4.6.2.3 and 4.6.2.4. Any section of the communication system that is isolated or separated by transformers shall use a consistent type of construction throughout the isolated or separated section.

4.6.2.2 Guarding

Communication circuits used in the operation of supply lines shall be isolated by elevation or otherwise guarded at all points accessible to the public.

4.6.2.3 Communication line construction

Communication circuits used in the operation of supply lines may be run as ordinary communication conductors, provided that

(a) such circuits comply with Clause 4.6.1.2 or 4.6.1.3;
(b) such circuits occupy the position indicated for normal level arrangement;
(c) such circuits meet the requirements for clearance from supply circuits, as specified in this Standard, at crossings, proximities, or on jointly used structures; and
(d) adequate protective measures are applied to prevent the communication circuit from exceeding 300 V line-to-ground under normal low-frequency induction conditions.

4.6.2.4 Supply line construction

Communication circuits used exclusively in the operation of supply lines shall be classified as supply circuits where they do not comply with Clause 4.6.2.3. These circuits shall comply with all requirements for the supply lines with which they are used.

4.7 Changes in the vicinity of a line

Where a line exists (or is under construction), no changes should be made in its vicinity such that any clearance and separation with respect to that line will be reduced below the minimum clearance and separation required by this Standard or pertinent regulations. Reduction below required minimum clearances and separations can be avoided by using one or both of the following precautions:

(a) any desired changes are planned or carried out such that the line's clearances and separations will not be affected; and
(b) any necessary alterations to the line are arranged in advance by agreement with the owner of the line.

Notes:

(1) *Changes that can affect the clearances and separations of a line include the following:*
  (a) construction or alteration of any structure or other line in the vicinity;
  (b) changes in the elevation or surface condition of the land under or near the line; and
  (c) changes in the use or accessibility, or both, of the land under and near the line.

(2) *When a line is being designed or constructed in a location where there are definite and specific plans for other construction or changes in the topography, and these changes are made known to the utility, sufficient additional clearance or separation should be provided, by mutual consent of the parties involved, to accommodate such construction or changes, where practicable.*

5 Clearances, separations, and spacings

5.1 Scope
Clause 5 specifies clearances, separations, and spacings involving overhead line components, and their relationship to each other, to the ground, and to other plant. The clearances, separations, and spacings specified in Clause 5 are the basic values required for public safety and are not intended to address the limits of approach to electrical installations as specified in occupational health and safety regulations.

5.2 General application

5.2.1 Construction and day-to-day clearances
The clearances specified in Clause 5 for wires and conductors are minimum values related to maximum specified loads and service conditions and represent design limits rather than clearances for construction or day-to-day operation. Clearances under day-to-day conditions are greater than the minimum clearances specified in Clause 5 when loads and service conditions are less severe than specified maximum conditions. Clearances provided at the time of construction shall by design be sufficiently greater than the minimum clearances specified in Clause 5 to ensure that the actual clearances under maximum specified loads and service conditions meet minimum clearance requirements.

Note: *Clearances specified in the* Canadian Electrical Code, Part I, *apply at the time of installation rather than under specified maximum conditions and are therefore larger than those specified in the* Canadian Electrical Code, Part III, *for the reasons given in this Clause.*

5.2.2 Vertical design clearances at maximum sag
Unless otherwise specified, vertical clearances shall apply under conditions of maximum sag of the wires or conductors, whether thermally loaded (see Clause 5.2.5) or physically loaded under wind and/or ice (see Clause 7). The calculation of final maximum thermal sag for a conductor shall be based on its final unloaded ambient air sag condition.

5.2.3 Horizontal design clearances
Horizontal clearances shall apply under the swing conditions specified in Clause 5.2.7.

5.2.4 Conductor classification for clearances
Supply cables insulated for the applicable voltage and having a continuous metallic sheath that is effectively grounded and capable of carrying the full fault current available at the applicable voltage may be classified as bare 0 to 750 V line-to-ground conductors. All other supply cables or assemblies shall have the same clearances as open conductors operating at the applicable voltage.

5.2.5 Conductor temperature for thermal loading conditions

5.2.5.1
For wires or conductors carrying currents less than 1/3 of their rated ampacity, the design conductor temperature for the thermal loading condition shall be 50 °C.

Note: *See the definition of rated ampacity in Clause 3.*

5.2.5.2
For wires or conductors carrying currents greater than 1/3 of, but not exceeding, their rated ampacity, the design conductor temperature for the thermal loading condition shall be
(a) calculated in accordance with ANSI/IEEE 738 for the anticipated worst-case conditions; or
(b) 100 °C for bare conductors and 80 °C for covered conductors.

5.2.5.3

For wires or conductors carrying currents greater than their rated ampacity, the design conductor temperature for the thermal loading condition shall be calculated in accordance with ANSI/IEEE 738 for the anticipated worst-case conditions.

5.2.6 Neutral conductors and lightning protection wires

Neutral conductors and lightning protection wires associated with supply circuits shall have the same clearances as the phase wires of the circuit with which they are associated. However, neutral conductors that are effectively grounded throughout their length and associated with circuits whose voltage does not exceed 26 kV, and lightning protection wires that are effectively grounded, may have the same clearances as 0 to 750 V conductors, except where lesser clearances are permitted by this Standard.

5.2.7 Wire or conductor swing for horizontal design clearances

Where specified horizontal clearances are required by this Standard to include an allowance for the swing of conductors, the deviation of the conductor shall be calculated as follows:

(a) In exposed and open terrain, the horizontal deviation of the wire or conductor from its position at rest shall be as specified in Table 1.

(b) In locations where the span of wire or conductor is partly sheltered from the full effect of transverse winds by buildings or other construction, as in built-up commercial or residential areas, the horizontal deviation of the wire or conductor from its position at rest shall be as specified in Table 1.

(c) Where wires or conductors are fully sheltered from transverse wind loads that could cause them to swing, such as along narrow urban streets or lanes and between buildings that reach at least the height of the conductor or wire on both sides, no allowance is required for horizontal deviation.

(d) For the purpose of determining wire or conductor swing, the sag at the point under consideration shall be taken as the final unloaded sag at a conductor temperature of 40 °C or, alternatively, the 2.5% July design temperature (as specified in the *National Building Code of Canada*) applicable to the area under consideration. The 2.5% July design temperature is the temperature at or above which 2.5% of the July hourly ambient temperature occurs.

(e) Where suspension insulators that are not restrained from swinging transversely are used, the length of the insulator string shall be added to the conductor sag for the purpose of determining the sag used in Table 1.

5.3 Vertical design clearances and separations

5.3.1 Vertical design clearances of wires and conductors above ground or rails

5.3.1.1 Basic clearances

The minimum vertical clearances of wires and conductors above ground or rails shall be as specified in Clause 5.2 and Tables 2 and 4, except that

(a) the clearances over roadways or other areas where vehicles are expected to be used are based on a combined vehicle and load height of 4.15 m. For provinces and territories that permit the combined vehicle and load height to exceed 4.15 m, the applicable clearance specified in Tables 2 and 4 shall be increased by the amount by which the allowable combined vehicle and load height exceeds 4.15 m;

(b) for altitudes exceeding 1000 m and where voltages exceed 50 kV, the clearances specified in Table 2 shall be increased by 1% for each 100 m increase in excess of 1000 m above mean sea level;

(c) because the rail level of a railway where ballast is used is not fixed, when any line that crosses a railway is constructed or altered, an additional 0.3 m of vertical clearance above rails shall be provided, unless a lesser amount is mutually agreed upon, to permit normal subsequent ballast adjustments without encroaching on the specified minimum clearance;

(d) when a line that crosses or will cross any public thoroughfare likely to be travelled by road vehicles is constructed or altered, an additional 0.225 m of vertical clearance shall be provided to permit the road surface to be raised by this amount during subsequent road work operations without encroaching on the specified minimum clearance; and

(e) where snow is not cleared away, additional clearance equal to the mean annual maximum snow depth shall be provided, making due allowances for maximum conductor sag at prevailing temperatures.

Note: *See Table D.1 for information on mean annual maximum snow depth.*

5.3.1.2 Special equipment and operations

Specified vertical clearances above ground or rails do not normally provide for the operation of special equipment such as cranes or other aerial devices used for construction or maintenance underneath the conductors, nor for operations that are carried out in special locations such as railway yards, materials handling and storage yards, truck loading or unloading areas, farm feed lots, and similar premises. At locations where special operations are frequent, suitable additional clearance beyond the minimum specified in this Standard might have to be provided as mutually agreed upon between the parties concerned.

5.3.2 Vertical separations (heights) of supply equipment from ground

5.3.2.1

Minimum vertical separations from ground for supply equipment such as cable terminals, arresters and line switches, transformers, regulators, and capacitors shall be as specified in Table 5.

5.3.2.2

There is no vertical separation requirement for communication terminals, supply switch handles, and control, police, and fire-alarm boxes, provided that they are effectively grounded and do not obstruct pedestrian traffic.

5.3.3 Clearances over waterways

5.3.3.1 General

Clause 5.3.3 specifies requirements for vertical clearances of wires and conductors above navigable waterways, including commercial, recreational, and secondary waterways.

Notes:

(1) *Navigable waters are governed by the* Navigable Waters Protection Act *under the authority of Transport Canada. Crossings over navigable waterways are subject to the provisions of the* Navigable Waters Protection Act *and might therefore require approval by Transport Canada through regional offices.*

(2) *Obstruction markings of wires, conductors, and structures are not covered by this Standard. The Civil Aviation Branch of Transport Canada should be consulted to determine aerial marking requirements. Transport Canada Standard 621.19 provides guidance in this area.*

5.3.3.2 Basic vertical clearances

The minimum vertical clearances of wires and conductors above waterways shall be as specified in Table 3, except that

(a) for areas where vessel heights are known to exceed the reference vessel height at the time of design, the clearance specified in Table 3 shall be increased by the difference between the taller vessel and the reference vessel height specified in Table 3; and

(b) for elevations above 1000 m and where voltages exceed 50 kV, the clearances specified in Table 3 shall be increased by 1% for each 100 m or part thereof in excess of 1000 m above mean sea level.

5.3.3.3 Determining minimum vertical clearances

When determining minimum vertical clearance, the sag of the wire or conductor shall be calculated in accordance with Clause 5.2.2, except in the case of uncharted waterways that are used exclusively for recreational navigation, for which the vertical clearance shall be based on the maximum sag of the thermally loaded conductor above the reference water level. The reference water level used shall be the ordinary high-water level (OHWL).

OHWL elevations shall be determined by means of establishing survey control points tied into the existing Geodetic Survey of Canada or Canadian Hydrographic Service benchmarks.

Note: *The OHWL elevation and the data used to determine it should be recorded and included in the application for approval.*

5.3.4 Maximum height of wires and equipment above ground in the vicinity of airports

The heights of wires, supporting structures, and equipment on land adjacent to, surrounding, or near an airport in Canada are subject to the regulations of Transport Canada and are not covered by this Standard. Transport Canada TP 1247 provides guidance in this area.

5.4 Horizontal design clearances of wires and conductors from railway tracks

5.4.1

Where wires and conductors are along a railway track or tangential to a curved track and where, under maximum sag conditions, the wires and conductors provide less than the minimum vertical clearance above rails required by Clause 5.3.1, minimum horizontal clearances shall be provided in accordance with Clauses 5.4.2 and 5.4.3. This minimum horizontal clearance shall be the distance between the vertical projection of the inside edge of the top of the nearest rail and the nearest position of the wire under the conditions of swing specified in Clause 5.2.7.

5.4.2

Where there is no curvature of railway tracks, the horizontal clearances shall be as specified in Table 6.

5.4.3

At a point of curvature of a railway track, the horizontal clearances shall be as specified in Table 6, with an increment of 25 mm added for each degree of curvature. In addition, where the wire is closer to the low side of tracks that are at different elevations, a further increment of 2.5 mm shall be added for each millimetre of superelevation. (The total of these two increments shall not exceed 0.75 m, and the value of 0.75 m may be used in place of calculations.)

5.5 Horizontal separations of supporting structures from railway tracks

Note: *Side separations as specified in Clause 5.5 are not customary construction separations but minimum separations for circumstances where greater separations cannot be achieved. To allow working space for normal maintenance operations, railways do not ordinarily permit poles, guys, etc., to be placed on the railway right-of-way less than 9 m from the track centreline (where space permits). On narrower rights-of-way, structures and guys should be placed as far as possible from the centreline of the nearest track.*

5.5.1

Any part of a supporting structure not complying with the vertical clearance requirements of Clause 5.3.1 shall be provided with minimum horizontal separations from railway tracks in accordance with Clauses 5.5.2 to 5.5.5. The minimum horizontal separation shall be the distance between the vertical projection of the inside edge of the top of the nearest rail and the nearest position of the structure.

5.5.2

Where there is no curvature of the railway tracks, the minimum horizontal separation between the tracks and supporting structures shall be as specified in Table 7, but shall be increased, where applicable, to comply with Clauses 5.5.4 and 5.5.5.

5.5.3
At a point of curvature of the railway tracks, the minimum horizontal separation shall be that specified in Table 7, plus the increment required by Clause 5.4.3. This minimum horizontal separation shall be increased, where applicable, to comply with Clauses 5.5.4 and 5.5.5.

5.5.4
At loading sidings, sufficient space shall be left for a driveway, in accordance with the stated needs of the railway.

5.5.5
In all cases, horizontal separations shall be great enough to permit an unobstructed view of signals, signs, and similar equipment.

5.6 Horizontal separations of supporting structures from fire hydrants, street corners, curbs, and other buried services

5.6.1 Horizontal separation from fire hydrants
Supporting structures, including guys or attachments, that are less than 2 m above the top of a fire hydrant shall have a minimum horizontal separation from the hydrant of 1 m.

5.6.2 Horizontal separation from street corners
Supporting structures, including guys, shall be located as far as practicable from the beginning of curvature of the roadway.

5.6.3 Horizontal separation from curbs

5.6.3.1
Structures shall be located at least 150 mm from the edge of a curb, measured away from the travelled portion of the roadway.

5.6.3.2
Where crossarms and other attachments such as guys provide less than the minimum vertical separation above roads required for guys in Clause 5.3.1, such attachments shall have the minimum horizontal separation specified in Clause 5.6.3.1.

5.6.4 Horizontal separation from other buried services
A minimum separation of 0.6 m shall be maintained between the edge of a pole and the nearest face of other buried services in order to permit pole replacement without damage to other services.

5.7 Clearances of wires, conductors, and equipment from buildings, signs, bridges, swimming pools, and similar plant

5.7.1 General
Wires and cables shall not interfere with the normal use of balconies, doors, fire escapes, windows, permanent ladders, catwalks, etc.

5.7.2 Clearances of supply conductors permanently attached to buildings
Where the permanent attachment of supply conductors to buildings is necessary (e.g., for a service conductor), the minimum clearance of conductors from the surface of buildings as specified in Table 8 shall apply under the following conditions:

(a) vertical clearances shall apply under conditions of maximum sag of the conductor; and

(b) horizontal clearances shall apply where the conductor is in the position of swing, as determined in accordance with Clause 5.2.7.

5.7.3 Clearances of wires and conductors passing by or over buildings, signs, billboards, lamps, traffic signs, standards, and antennas (not attached)

5.7.3.1 Basic clearances

The minimum horizontal and vertical clearances from wires and conductors to buildings, signs, and similar plant specified in Table 9 shall apply under the following conditions:

(a) clearances shall apply to any part of a building, including balconies, fire escapes, antennas and their supporting structures, and other permanent fixtures;
(b) vertical clearances shall apply under conditions of maximum sag of the wire or conductor;
(c) horizontal clearances shall apply when the wire or conductor is in the position of swing, as determined in accordance with Clause 5.2.7; and
(d) guy wires, communication cables, and drop wires shall not be allowed to rub against buildings or other plant.

5.7.3.2 Application of clearances

Note: *In this Clause, the word "building" is used to refer to any of the plant specified in Clause 5.7.3.1.*

The minimum required vertical clearance at any given point on a building shall apply when the wire or conductor is above that point and closer horizontally than the specified minimum horizontal clearance.

The minimum required horizontal clearance shall apply when the wire or conductor is closer vertically to the point in question than the specified minimum vertical clearance.

The vertical clearance from a wire passing under a building projection to the nearest point of that projection shall be not less than the horizontal clearance requirement.

Furthermore, the minimum clearances specified in this Clause shall apply to all points on the wire or conductor and all points on the building.

Where buildings contain flammable materials or explosives, the need for additional clearances shall be investigated.

When clearances as specified in Table 9 are applied, allowance shall be made for the swing of the sign or similar plant.

5.7.3.3 Conductors energized above 200 kV

When buildings are located adjacent to a transmission corridor with lines operating above 200 kV, a study shall be conducted to determine suitable clearances between conductors and buildings greater than those specified in Table 9, taking into account electrostatic induction. In these situations, additional measures might be necessary to mitigate the effects of electrostatic induction on the building, its occupants, or construction and maintenance personnel. Measures that may be taken include

(a) change in conductor height;
(b) increased right-of-way width;
(c) installation of shielding between the transmission line and buildings constructed at the edge of the right-of-way;
(d) modification of the building configuration; or
(e) grounding of metallic objects.

Note: *The list in this Clause is not comprehensive.*

5.7.3.4 Conductors energized at 230 kV phase-to-phase or greater

When overhead or underground low-voltage or communication wiring is located under a transmission line or adjacent to a transmission corridor, with the transmission lines operating at 230 kV (phase-to-phase) or greater, an electromagnetic induction study shall be conducted to determine suitable clearances between transmission conductors and low-voltage wiring, less than or equal to 22 kV (line-to-ground). In specific

situations, measures might be necessary to mitigate the effects of electromagnetic induction on low-voltage and communication wiring for the safety of workers and/or building occupants and the supply of undisturbed regulated low-voltage power supply. Measures that may be taken include
(a) avoiding installation of low-voltage or communication wires parallel to high-voltage lines;
(b) installing low-voltage or communication wires perpendicular to high-voltage lines;
(c) changing low-voltage or communication feeds to multiple sources;
(d) increasing plant's supply voltage from nominal 110 V; or
(e) increasing separation between low-voltage or communication wires and high-voltage lines.

5.7.4 Clearances from supply wires and conductors to bridges

5.7.4.1 General

Clause 5.7.4 specifies clearances for supply wires and conductors that are attached to or pass under, over, or near a bridge. Clause 5.7.4 does not cover clearances over a bridge used solely for a railway or over portions of a bridge normally traversed by pedestrians, road vehicles, or trains. Clearances over or adjacent to portions of the bridge that are normally traversed by pedestrians, road vehicles, or trains are specified in Tables 2 and 4.

5.7.4.2 Basic clearances for supply conductors

The minimum clearance from supply conductors to bridges as specified in Table 10 shall apply under the following conditions:
(a) vertical clearances shall apply under conditions of maximum sag for a conductor above the portion of the bridge involved, and shall apply to the initial sag at the lowest anticipated temperature for the area for a conductor under the portion of the bridge involved; and
(b) horizontal clearances shall apply when a wire is in the position of swing, as determined in accordance with Clause 5.2.7.

5.7.4.3 Operation of bridges

Wires or cables shall not interfere with the use or operation of a bridge.

5.7.4.4 Guarding of trolley contact conductors

Where the trolley contact conductor is located such that a trolley pole leaving the conductor could make simultaneous contact between the conductor and the bridge structure, suitable guards shall be provided. Guards shall be substantial inverted troughs of non-conducting material located above the contact conductor or other suitable means of preventing contact between the trolley pole and the bridge structure.

5.7.5 Minimum separation of equipment and clearances of conductors over and adjacent to swimming pools

Conductors and equipment shall not be located over or adjacent to a swimming pool unless it is not practical to locate them elsewhere. If equipment and conductors need to pass over a swimming pool or the area surrounding a pool, the minimum clearance of conductors and separation of equipment from swimming pools shall be as specified in Table 11 and as shown in Figure 1.

Conductor sags shall be determined in accordance with Clauses 5.2.5 and 5.2.7 for vertical and swing conditions.

5.7.6 Horizontal separations from supply equipment to buildings

The minimum horizontal separations from supply equipment to buildings shall be as specified in Table 12. The supply equipment shall not inhibit the normal use of balconies, doors, windows, fire escapes, permanent ladders, catwalks, and other such structures.

5.7.7 Clearances from propane tanks

In order to conform to CSA B149.2, clearances from propane tanks shall be as follows:
(a) supply lines shall not be installed over propane tanks of an aggregate capacity of 7600 L or greater;
(b) overhead supply conductors less than or equal to 22 kV shall have a horizontal clearance at rest of 7.6 m from propane tanks that have an aggregate capacity of 7600 L or greater; and
(c) overhead supply conductors greater than 22 kV shall have a horizontal clearance at rest of 15 m from propane tanks that have an aggregate capacity of 7600 L or greater.

5.7.8 Clearances from other flammable hazards

All potentially hazardous areas, including gasoline filling stations, storage tanks, fuel pumping and regulator stations, or above-ground gas pipelines, shall be reviewed and suitable safety measures shall be agreed upon by the parties involved. Construction of lines over such installations shall be avoided where practicable. Where overhead lines need to be used for such installations, Grade 1 construction shall be used.

Note: *Devices that can emit sparks or glowing embers, such as fuses and arresters, should not be located on poles adjacent to fuelling stations.*

5.7.9 Clearances for other wire facilities

The minimum clearance between an aerial tramway, ski tow, T-bar, chairlift, or similar equipment and an overhead power line greater than 750 V, measured horizontally between the vertical planes passing through the closest points of the equipment and the overhead power line, shall be 15 m.

5.8 Clearances between wires and conductors of one line and wires, conductors, and structures of another line

5.8.1 Vertical clearances at crossings of line wires and conductors supported by different structures

5.8.1.1 Basic clearances

The minimum vertical clearance between wires or conductors crossing each other and on different structures shall be as specified in Table 13. Table 14 covers the clearances for crossings over aerial tramways, including gondolas, T-bars, and chairlifts.

The clearances specified in Tables 13 and 14 shall apply under the following conditions:
(a) the upper wire or conductor is in its maximum sag position; and
(b) the lower wire or conductor is assumed to form a straight line between its points of support.

Note: *This straight line is called the "line of sight" of the lower line.*

5.8.1.2 Reduced clearances

Where the ice- and wind-loaded sag of the lower wire or conductor exceeds 6 m at the point where it crosses under the upper wire or conductor, the clearance in Table 13 may be reduced by one-half the difference between the ice- and wind-loaded sag and 6 m. Particular attention shall be paid to the possibility of sudden ice drop-off, which could cause the lower conductor to jump upwards.

5.8.1.3 In-span vertical clearances between supply and communication conductors

Where supply conductors between 0.75 and 22 kV cross communication conductors, a common structure at the point of crossing shall be provided, where practicable, to which the supply and communication conductors shall be attached. Where coordinated electrical protection cannot be achieved, a higher grade of construction shall be used.

5.8.2 Clearances between conductors supported by different structures but not crossing each other

Where conductors are supported by different structures but do not cross each other, they shall have
(a) a minimum vertical clearance in accordance with Clause 5.8.1; or
(b) minimum horizontal clearances with the conductors in the at-rest position that are equal to the sum of the calculated conductor displacement due to a transverse conductor swing plus the appropriate increment from Table 15. This conductor displacement shall be calculated in accordance with the following:
  (i) where the conductor of one line is free to swing so that it approaches the conductor of a second line at a point where this conductor is not free to move (e.g., a structure of one line near the midspan position of the second line), the conductor displacement at midspan shall be calculated in accordance with Clause 5.2.7; and
  (ii) where lines run alongside each other and the adjacent conductors are free to approach one another, the conductor of the line having the greater sag shall be considered to be displaced one-half the distance calculated in accordance with Clause 5.2.7, and the conductor of the second line shall be considered at rest.

5.8.3 Clearances in any direction between conductors of one line and supporting structures of another line

5.8.3.1 Basic clearances

The minimum clearances in any direction between conductors of one line and supporting structures of another line, where conductors are not attached to the supporting structure of the second line, shall be as specified in Table 16. The clearances shall apply for the more applicable of the following conditions:
(a) the conductor is at its maximum sag condition; and
(b) the conductor is in a position of swing, as specified in Clause 5.2.7.

5.8.3.2 Climbing space

The climbing space (see Clause 4.1.4) on a structure of one line shall not be reduced by a conductor of another line.

5.8.3.3 Joint-use common structure

Where communication circuits are in joint use with supply conductors rated up to 50 kV, midspan structures that support only the communication conductors shall be avoided. To ensure adequate clearances are maintained, the supply conductors and communication facilities shall be attached to the common structure.

5.9 Separations of supply-line conductors and conductor supports on the same supporting structure

5.9.1 Horizontal separations or separations within 45° of the horizontal of supply-line conductors on the same supporting structure

5.9.1.1

The minimum separations between supply-line conductors of the same circuit or different circuits that are at the same level or within 45° of the horizontal on the same supporting structure shall be as specified in Table 17.

5.9.1.2

When applying the separations specified in Table 17, voltages shall be
(a) for dc, the voltage differences between the conductors involved;
(b) for ac conductors in the same circuit, normal operating phase-to-phase voltages; and

(c) for ac conductors in two different circuits, the sum of the normal operating phase-to-ground voltages of both circuits.

5.9.1.3

Where suspension insulators are used and are not restrained from swinging transversely, the sags specified in Table 17 shall include the length of the insulator string.

5.9.2 Vertical separations and clearances of supply-line conductors attached to the same supporting structure

5.9.2.1 Minimum vertical separations between supply-line conductors attached to the same supporting structure

Where supply-line conductors of the same or different voltage classifications are supported by the same structure, but at different levels, the minimum vertical separations shall be as specified in Table 18. Where galloping or ice drop-off are likely to occur, increased separation should be considered to ensure adequate in-span clearance.

5.9.2.2 Vertical spacings between supply-line conductors of 0 to 750 V on vertical brackets

The average vertical spacings between supply-line conductors of 0 to 750 V that are supported on vertical brackets shall be not less than those specified in Table 19 and shall apply under the following conditions:

(a) conductors shall be erected and maintained in a manner that prevents in-span contact under normal operating conditions; and

(b) the minimum vertical spacing between the top conductors supported on the vertical bracket and the centre of the nearest crossarm above shall be 600 mm.

5.9.2.3 In-span vertical clearances between supply-line conductors of the same circuit

The minimum in-span vertical clearance between supply-line conductors of the same circuit that are attached to the same supporting structure shall be as specified in Table 20, and shall apply

(a) at maximum sag for conductors of the same voltage class;

(b) at final unloaded sag at a 40 °C design conductor temperature for neutrals or conductors of 0 to 750 V, which are considered to be of the same circuit of a voltage class other than 0 to 750 V, and are attached below the other circuit conductors; and

(c) where the maximum sag of the circuit conductors (other than 0 to 750 V) associated with the neutral (i.e., the circuit phase conductors) is determined by the ice-loading conditions, the conditions for the neutral or conductors of 0 to 750 V shall be the final unloaded sag at a 0 °C design conductor temperature.

5.9.2.4 In-span vertical clearances between supply-line conductors of different circuits

The minimum in-span vertical clearance between supply-line conductors of different circuits of the same or different voltage classes and attached to the same supporting structure shall be as specified in Table 21, and shall apply under the following conditions:

(a) the upper conductor shall be assumed to be at maximum sag; and

(b) the lower conductor shall be assumed to be at initial unloaded sag at the mean annual temperature.

5.9.3 Separations in any direction other than horizontal or vertical between supply-line conductors

The separations in any direction other than horizontal or vertical between supply-line conductors supported by the same supporting structure shall be not less than the greater of

(a) the value for vertical separations between conductors specified in Clause 5.9.2; or

(b) the value for horizontal separations between conductors specified in Clause 5.9.1.

5.9.4 Clearances in any direction from communication-line conductors to guys, span wires, or grounding conductors carried in aerial spans and attached to the same supporting structure

The minimum clearance in any direction in the vicinity of a structure from communication-line conductors to guys, span wires, or grounding conductors carried in aerial spans shall be 75 mm.

5.9.5 Separations or clearances in any direction from supply conductors to other supply plant attached to the same supporting structure

The minimum separations or clearances in any direction between supply conductors and supply plant (e.g., vertical or lateral conductors, guys, and lightning protection wires) shall be as specified in Table 22. These separations or clearances shall apply under the following conditions:

(a) The voltage specified in Table 22 for ac conductors shall be taken as
  (i) voltage-to-ground for clearance between conductors and crossarms, structures, or span or guy wires;
  (ii) phase-to-phase voltage for clearance between conductors of the same circuit; and
  (iii) the sum of the voltages-to-ground for any two conductors of different circuits.
(b) Voltage for dc conductors shall be taken as
  (i) voltage-to-ground for clearance between a conductor and a supply, span, or guy wire; and
  (ii) the sum of the voltages-to-ground for clearance between any two conductors.
(c) Where suspension insulators that are not restrained from swinging transversely are used, the clearances shall apply with one conductor at rest and the other conductor in the position of swing as determined in accordance with Clause 5.2.7.

5.10 Joint-use clearances and separations — Supply and communication plant

5.10.1 Vertical separations at the structure — Normal level arrangement

5.10.1.1

The minimum vertical separations at the structure shall be in accordance with Table 23. Greater separation might be necessary in order to meet the clearances in the span specified by Clause 5.10.3.

5.10.1.2

Luminaires and associated brackets shall be effectively grounded unless they are located more than 1 m above the communication plant. Supply cables and wires associated with the luminaire shall be insulated and protected by a covering that provides suitable mechanical protection, unless they are located more than 1 m above the communication plant.

5.10.1.3

Switch handles shall be separated by at least 100 mm from the communication plant. The metal frames and operating rods in the vicinity of the joint-use space shall be effectively grounded or shall be insulated above the communication working space.

5.10.1.4

Supply service to the communication power supply shall be provided by an effectively grounded, continuous metal-sheathed cable or enclosed in a conduit.

5.10.1.5

Common structure crossings shall be classified as joint use.

5.10.1.6
Where the restrictions of Clause 5.10.1.7 are not met, Option A of Table 23 shall be used.

5.10.1.7
Option B of Table 23 may be used, provided that
(a) work on the communication plant is carried out without the use of a platform and/or a tent; and
(b) communication personnel are restricted to positions where only the head and shoulders project above the communication plant.

5.10.2 Vertical separations at the structure — Inverted level arrangement

5.10.2.1 Inverted level arrangement
For inverted level arrangement, the minimum vertical separation between the uppermost attachment of supply plant of 0 to 750 V and the lowest attachment of communication plant shall be at least 1200 mm, and preferably 1500 mm. Inverted level arrangement with supply plant of 0.75 to 22 kV should be avoided; however, where it needs to be used, the minimum separation shall be 1500 mm. Inverted level arrangement with supply plant of greater than 22 kV should not be used.

5.10.2.2 Wireless communication antenna
For a wireless communication antenna installed on a joint-use structure above supply plant, the minimum separation between the antenna and the supply plant shall be
(a) 1200 mm for supply plant of 0 to 750 V (only secondary on pole);
(b) 1500 mm for supply plant greater than 750 V and less than or equal to 22 kV; and
(c) 2400 mm for supply plant greater than 22 kV and less than or equal to 50 kV.

Wireless communication attachments shall not be attached between primary and secondary supply conductors.

Installation of communication antennae on structures supporting supply plant greater than 50 kV shall be subject to agreement between the parties involved and the criteria of the owner of the supply plant.

5.10.3 In-span vertical clearances

5.10.3.1
Clause 5.10.3 shall not apply to installations covered by Clause 5.10.6.

5.10.3.2
The minimum in-span vertical clearances between supply conductors and communication wire or cable under the condition of maximum sag in the supply conductors shall be as specified in Table 24.

5.10.3.3
For effectively grounded neutral conductors of multi-grounded neutral distribution circuits that do not exceed 26 kV and are located 300 mm or more below phase conductors,
(a) on spans less than or equal to 75 m, minimum separations at the structure shall be adjusted such that the neutral does not fall below the line of sight of the highest communication conductor; and
(b) on spans greater than 75 m, the common grounded neutral may sag below the line of sight of the communication attachments, provided that it is a minimum of 300 mm above the in-span communication conductors under
    (i) maximum sag due to maximum temperature or to maximum winter loads in the supply circuit; and
    (ii) sag at 45 °C for the communication circuit.

5.10.4 Vertical runs attached to surface of structure

5.10.4.1
The vertical run shall be separated from span or guy wires by at least 50 mm. Vertical runs enclosed in a moulding of adequate electrical insulating and mechanical properties do not require separation in addition to that provided by the moulding; however, the guy or span wire shall not abrade the moulding.

5.10.4.2
Vertical runs of communication and supply systems shall meet the requirements for risers specified in Clause 4.2.4.

5.10.5 Vertical runs not attached to surface of structure
Lamp leads or trolley feeder taps that run directly from a supply crossarm through or within 1 m vertically from the communication line plant shall be held taut at least 1 m from the surface of the structure, unless insulated. Where passing through the communication plant, these conductors shall have a minimum clearance of
(a) 0.3 m beyond the end of communication crossarms;
(b) 0.15 m from the communication drop wire; and
(c) 0.5 m from the communication cable, where practicable.

Where the clearances of Items (a) to (c) cannot be achieved, conductors shall be provided with insulation for the applicable voltage and type of service.

5.10.6 Clearances and separations between drops and service conductors on buildings

5.10.6.1
Clause 5.10.6 applies where both drops and service conductors are attached to the exterior surface of a building or to an exterior support attached to a building (e.g., a service mast).

5.10.6.2
The minimum clearance or separation between drops and service conductors attached to buildings shall comply with the requirements of the *Canadian Electrical Code, Part I*, Rule 60-510. For the purpose of Clause 5.10.6, bare neutrals associated with insulated service wires may be constructed according to the clearance or separation specified for insulated conductors in this Standard.

The service conductors and drops shall not come into contact under normal operating conditions. Supply service conductors and communication service drops shall have a minimum separation of 300 mm at any point in the span, including the point of attachment to the building, at the time of installation. The conductors shall be insulated and the clearance specified in Table 23 shall be maintained between the two services at the pole.

5.11 Guys and guy attachments

5.11.1 Guy attachments — Joint-use structures

5.11.1.1 Supply guy attachments
Supply guy attachments on joint-use structures shall be attached not less than 0.75 m above or below communication attachments. Where this separation is not possible, the largest practical separation shall be used.

5.11.1.2 Communication guy attachments
Communication guy attachments shall be located such that they do not restrict the working space and climbing space around the communication attachments.

5.11.2 Guys attached to joint-use structures

5.11.2.1 Clearances between guys and plant of another system

The clearance between a guy that is attached to a joint-use structure and plant of another system (not supported by the same joint-use structure) shall be as specified in Table 25. Guys shall not abrade one another.

5.11.2.2 Clearances or separations between guys and other plant attached to a joint-use structure

At any point, with the exception of attachments, the clearance or separation between a guy and other plant attached to a joint-use structure shall be as specified in Table 26. For vertical separations between attachments at joint-use structures, see Clause 5.11.1.

5.11.3 Guys attached to remote structures

Guys that extend from supply structures (not involved in joint use) to joint-use structures shall be constructed such that they will not create a hazard to workers on either structure. This may be accomplished by effectively grounding the guy or by placing one or more suitable strain insulators in the guy.

5.11.4 Guys attached above current-carrying supply plant

Where the guy attachment to a joint-use structure is located above any item of live or current-carrying supply plant greater than 750 V, and where the guy passes within 1 m of the communication line plant (excluding the communication guy), the guy shall be effectively grounded.

Where the guy cannot be grounded,

(a) the portion of the guy having inadequate clearance from the communication line plant shall be electrically isolated with guy insulators; or

(b) equivalent insulation shall be applied.

6 Minimum grades of construction

6.1 General

For the purposes of strength requirements for communication and supply lines less than or equal to 69 kV nominal voltage (see Clause 8), lines shall be classified under the grades specified in this Clause on the basis of relative hazards. Grades of construction apply to structures, guys, crossarms, conductors (including cables and suspension strands), messengers, insulators, pins, and fastenings.

Where two or more conditions affect the grade of construction, the grade used shall be the strongest required under any of the conditions.

For supply lines at nominal voltages greater than or equal to 70 kV with no communication circuits in their proximity, the strength requirements of Clause 8 or of CSA C22.3 No. 60826 may be applied.

6.2 Order of grades

Grades of construction for supply and communication lines range from 1 through 3, with Grade 1 being the strongest.

6.3 Minimum grades of construction

6.3.1 General

Tables 27, 28, and 29 specify the minimum grades of construction for crossings, lines in proximity, and joint use, respectively.

6.3.2 Crossings

6.3.2.1
Table 27 specifies the minimum grades of construction for in-span crossings of supply and communication lines across highways and roads, private and public property, pipelines, waterways, railways, aerial tramways, and other communication and supply lines.

6.3.2.2
Common-structure crossings are classified as joint use. Span guys that form a crossing shall have the same grade and strength requirements as would the wire or cable attachments they support, if such attachments were to form the crossing themselves.

6.3.3 Proximities
Table 28 specifies the minimum grades of construction where structures or conductors of communication and supply lines are in proximity to any of the following: railways, highways and roads, pipelines, waterways, aerial tramways, other communication or supply circuits or lines, and other private or public property.

6.3.4 Joint use
Table 29 specifies the minimum grades of construction for joint use.

6.4 Insulated cabled supply conductors
Insulated supply conductors supported on, and cabled together with, an effectively grounded supporting conductor shall have the same grade of construction as open supply conductors of the same voltage.

6.5 Multiple crossings
Where a line crosses in one span over two other lines, the grade of construction of the uppermost line shall be not less than the strongest grade that would be required if one of the lower lines crossed the other lower line.

7 Weather loads and assumed loads according to deterministic design methods

7.1 General
Supply and communication lines shall be designed using either deterministic design methods or reliability-based design methods. Clause 7 specifies the deterministic method for calculating the loads to be applied to the design. Clause 8 specifies the deterministic method for calculating the strength of the structures required to support these loads safely.

The reliability-based methods outlined in CSA C22.3 No. 60826 should be used for supply lines greater than 70 kV (phase-to-phase).

Clause 7 specifies the assumed weather loads to be applied to the design of wire and cable attachments and to supports, including poles, towers, crossarms, pins, posts, insulators, and fastenings. For thermal loads, see Clause 5.2.5.

Non-linear analysis, including stability (buckling) check, is the method of analysis of wood structures that should be used. Linear analysis of wood pole structures continues to be utilized in some jurisdictions in accordance with historical utility practice and remains an option for users during a period of transition to non-linear analysis. The minimum load factors for linear analysis of wood pole structures, which were specified in past editions of this Standard, are reproduced in Table E.1.

Note: *Further information regarding the non-linear design method applied to poles, including sample calculations, can be found in ASCE Manual 111.*

7.2 Weather loads

This Standard recognizes the following four deterministic weather load conditions (see Table 30):
(a) severe;
(b) heavy;
(c) medium loading A; and
(d) medium loading B.

Loading classification shall be based on local experience and weather records. Annex C provides maps for guidance; the loads for the areas shown are considered the minimum, and local experience and information might permit the adjustment of these loads.

7.3 Assumed loads for wire and cable attachments

7.3.1

The assumed loads for wire and cable attachments shall be as follows:
(a) the assumed vertical load shall be the load, in N/m, of ice-covered wire and cable attachments, using the radial thickness of ice specified in Table 30 and assuming the density of ice to be 900 kg/m^3; and
(b) the assumed transverse load shall be the load, in N/m, created by the wind (in N/m^2, as specified in Table 30) acting horizontally on ice-covered wires and cable attachments.

7.3.2

The assumed maximum tensions of wire and cable attachments shall be the tension determined by the vector resultant of the assumed vertical and transverse loads specified in Items (a) and (b), respectively, of Clause 7.3.1.

7.3.3

The assumed load for conductor splices and dead-end fittings shall be 1.6 times the assumed maximum tension of the conductor containing the splice or dead-end fitting. The tap shall be of a type that does not reduce the capability of the conductor to withstand 1.6 times the assumed maximum tension.

7.3.4

When calculating the loads on conductors, the coating of ice shall be considered to be a hollow cylinder around the outer circumference. For cables with or without suspension strand (excluding cable assemblies in which the conductors are spaced more than 50 mm apart), the maximum diameter in any direction shall be used for calculating the wind and ice loads.

7.3.5

The values for ice, wind, and temperature specified in Table 30 shall be used to determine the assumed loads and maximum tensions.

7.4 General requirements — Loads on supports

7.4.1

The loads specified in Clauses 7.5 to 7.9 shall be used for calculating the strength requirements for supports, including poles, towers, foundations, guys, anchors, crossarms, pins, posts, insulators, and fastenings. The loads are divided into five categories, as follows:
(a) vertical loads: see Clause 7.5;
(b) transverse loads: see Clause 7.6;
(c) loads at angles: see Clause 7.7;
(d) longitudinal loads: see Clause 7.8; and
(e) loads for additional lines at angles to the main line: see Clause 7.9.

When calculating the loads to be applied to the structure, the assumed loads shall be combined vectorially, except for that portion of the assumed longitudinal load specified in Clause 7.8.2, which shall be considered separately.

7.4.2
The assumed loads for wood, concrete, and fibre-reinforced composite poles, for metal structures, and for guys shall be calculated by multiplying the loads of each category in Clause 7.4.1 by the appropriate load factors in Tables 31, 32, and E.1 for the type of load being considered.

7.4.3
For construction using pin-type insulators, the minimum assumed load in any direction on the pins, insulators, ties, or other conductor fastenings shall be 2.2 kN for each pin or conductor fastening.

7.5 Assumed vertical load on supports

7.5.1 General
The vertical load on poles, towers, foundations, crossarms, pins, posts, insulators, and fastenings shall be the vertical force produced by their own mass plus the mass of all attachments, including the ice-coated wire and cable attachments in the parts of adjacent spans carried by the support. The radial thickness of ice, as specified in Table 30, shall be applied only to wire and cable attachments. Structures and foundations shall have additional vertical loads applied due to the vertical component of associated guys or due to the difference in the elevation of supports.

7.5.2 Assumed vertical load on wood, concrete, and fibre-reinforced composite poles, metal structures, and towers
The assumed vertical load on wood, concrete, and fibre-reinforced composite poles, metal structures, and towers shall be calculated by multiplying the vertical load specified in Clause 7.5.1 by the load factors for vertical loads in Tables 31 and E.1.

7.5.3 Assumed vertical load on crossarm assemblies, pins, posts, insulators, and fastenings

7.5.3.1
The assumed vertical load on crossarm assemblies shall be the vertical load specified in Clause 7.5.1 multiplied by a load factor of 2.0. Crossarm assemblies shall be capable of supporting a vertical load of 1.0 kN at either extremity, in addition to supporting the mass of conductors without ice covering.

7.5.3.2
A built-up metal crossarm of a metal structure shall be designed to withstand the specified loads with load factors at least as large as those required for the tower or structure itself.

7.5.3.3
The assumed vertical load on pins, posts, insulators, and fastenings shall be the vertical load specified in Clause 7.5.1.

7.6 Assumed transverse load due to wind pressure

7.6.1 Assumed transverse load due to wind pressure on wire and cable attachments
The assumed transverse load on supports, due to wind pressure on the wire and cable attachments, shall be the wire loads specified in Clause 7.3.1(b), for the loading area concerned and using the transverse wire load due to 1/2 of the sum of adjacent spans.

7.6.2 Assumed transverse load on a structure

7.6.2.1
The assumed transverse load on a structure shall be the wire load specified in Clause 7.6.1 plus the load created by wind pressure (as specified in Table 30) on the surfaces of the structure without an ice covering. Where applicable, the wind load shall be calculated in accordance with Clauses 7.6.2.2 to 7.6.2.4.

7.6.2.2
For flat surfaces, latticed or otherwise, the assumed unit wind pressure shall be increased by 100%. Where flat-surfaced lattice structures are involved, the actual exposed area of one lateral face shall be increased by 50% to allow for the pressure on the front of the opposite face, and the wind pressure increase of 100% shall then be applied. The pressure calculated in this manner need not exceed the pressure that would be incurred on a solid structure of the same outside dimensions. The results obtained by more precise calculations may be substituted for the values obtained in accordance with the requirements specified in this Clause.

7.6.2.3
For structures carrying more than 10 wires, not including cables supported by strand, where the pin spacing does not exceed 380 mm, the transverse loads shall be calculated on 2/3 of the number of wires, with a minimum of 10 wires.

7.6.2.4
Transverse loads due to snow creep shall be taken into account in the design of the structure.

7.6.3 Assumed transverse load on pins, posts, insulators, and fastenings
The assumed transverse load on pins, posts, insulators, and fastenings shall be as specified in Clause 7.6.1.

7.6.4 Assumed transverse load on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guys
The assumed transverse load for wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guys shall be calculated by multiplying the transverse loads specified in Clause 7.6.2 by the appropriate transverse load factors in Tables 31, 32, and E.1.

For guyed wood or concrete poles, the pole at the point of guy attachment shall be designed to withstand the total assumed loads.

7.7 Assumed loads on supports at angles

7.7.1 General

7.7.1.1
Where a change in direction of wire or cable attachments occurs, the load shall be taken as the resultant load equal to the vector sum of the following:

(a) the transverse load as specified in Clauses 7.6.1 and 7.6.2;
(b) the load due to the change in direction of the line, i.e., the resultant of the longitudinal tensions in each direction away from the corner structure under the appropriate loading conditions; and
(c) where Grade 1 construction is called for, the longitudinal load specified in Clause 7.8.2.

7.7.1.2
The wind pressure shall be taken in such a direction that the loads specified in Clause 7.7.1.1 produce the maximum stress in the supports. As the wind does not usually act at right angles to each adjacent half-span simultaneously, proper reduction may be made to the transverse load to account for the

application of the wind to the wires at the appropriate angle, where the wind is assumed to be acting along or near the bisector of the angle.

7.7.2 Assumed loads at angles on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies

The assumed loads on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies at angles in the line shall be calculated by multiplying the loads specified in Clause 7.7.1 by the appropriate load factors in Tables 31, 32, and E.1.

7.7.3 Assumed loads at angles on crossarms, pins, posts, insulators, and fastenings

The assumed loads at angles on crossarms, pins, posts, insulators, and fastenings shall be the load specified in Clause 7.7.1 for the wire and cable attachments that they support.

7.8 Assumed longitudinal loads on supports

7.8.1 Assumed longitudinal load — Terminations or tension changes: Grades 1, 2, and 3

7.8.1.1 General

For terminations or tension changes, the longitudinal load on supports at crossing structures or within sections where Grade 1, 2, or 3 construction is called for in Table 27, 28, or 29 shall be understood to be as follows:

(a) for terminations at angles, or where the overhead wires end on a structure (e.g., where dead-end construction is used), the longitudinal load shall be taken as an unbalanced pull equal to the tensions of all conductors and supporting strands (including overhead ground wires) so terminated, under the appropriate loading conditions; and

(b) for terminations with spans in each direction, such as those employed in tension changes or at switch locations, the longitudinal load shall be understood to be as follows:
   (i) the vector sum of the tensions under the appropriate loading conditions; and
   (ii) where Grade 1 construction is called for, the longitudinal load as specified in Clause 7.8.2.

7.8.1.2 Assumed longitudinal load for terminations or tension changes on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies

The assumed longitudinal load for terminations or tension changes on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies shall be the load specified in Clause 7.8.1.1 multiplied by the appropriate load factors in Tables 31, 32, and E.1.

Note: *For angles affected by terminating, Clause 7.7.2 may be applied in place of Clause 7.8.1.2.*

7.8.1.3 Assumed longitudinal load for terminations or tension changes on crossarms, pins, posts, insulators, and fastenings

The assumed longitudinal load for terminations or tension changes on crossarms, pins, posts, insulators, and fastenings shall be the load specified in Clause 7.8.1.1 for the wire and cable attachments that they support.

The minimum assumed longitudinal load for terminations or tension changes on dead-end assemblies where Grade 1 or 2 construction is called for shall be 1.6 times the maximum tension of the conductor or conductors, as applicable.

The maximum allowable longitudinal load on crossarm assemblies using pin-type or post-type insulators shall be 3 kN, applied at the outer pins.

7.8.2 Assumed longitudinal load on crossing or end structures where Grade 1 construction is called for by Table 27, 28, or 29

Note: *The degree of longitudinal loading is determined by examining the strength of the structures adjacent to the sections required to be of Grade 1 construction.*

7.8.2.1 General

Clause 7.8.2 applies to those wires and cable attachments that are straight and continuous across the crossing or end structures (i.e., where normally balanced tensions are involved). Clause 7.8.2 is also used in the determination of the longitudinal load for angles and tension changes on structures where Grade 1 construction is called for by Table 27, 28, or 29 (see Clauses 7.7.1 and 7.8.1.1(b)).

7.8.2.2 Lines of Grade 1 construction

Where adjacent structures are built to Grade 1 construction on both sides of the section requiring Grade 1 construction, longitudinal loads need not be considered.

7.8.2.3 Lines of Grade 2 construction or weaker

Where supply lines or communication lines built to Grade 2 construction or weaker are adjacent to a section requiring Grade 1 construction, the longitudinal load for wires, self-supporting cables, and messengers shall be taken as an unbalanced pull in the direction of the section requiring the stronger grade, in accordance with 33-1/3 percent of the sum of all the tensions, under the appropriate loading conditions.

The assumed longitudinal load shall have a means of support as specified in Clause 8.4.4.

7.8.2.4 Assumed longitudinal load on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies

The assumed longitudinal load on wood, concrete, and fibre-reinforced composite poles, metal structures, towers, and guy assemblies shall be calculated by multiplying the loads specified in Clauses 7.8.2.2 and 7.8.2.3 by the appropriate load factors in Tables 31, 32, and E.1.

7.8.2.5 Assumed longitudinal load on crossarms, pins, posts, insulators, and fastenings

The assumed longitudinal load on crossarms, pins, posts, insulators, and fastenings shall be as specified in Clauses 7.8.2.2 and 7.8.2.3. For conductors supported by pin-type insulators, the assumed longitudinal load at each point of support shall be determined by dividing the wire load specified in Clauses 7.8.2.2 and 7.8.2.3 by the number of points of support, with each group of similar conductors being treated separately.

The minimum longitudinal load on crossarm assemblies using pin-type or post-type insulators shall be 2.2 kN, applied at the outer pin or post.

7.8.3 Assumed longitudinal load — Wire and cable attachments not involved in terminations or tension changes where Grade 2 or 3 construction is called for by Table 27, 28, or 29

Longitudinal load (as specified in Clause 7.8.2) need not be considered where Grade 2 or 3 construction is called for by Table 27, 28, or 29.

7.9 Assumed loads on a main line at a common structure

7.9.1

The line whose circuit is attached to the common structure requiring the strongest grade shall be called the main line. Where a main-line structure also supports wire and cable attachments of one or more other lines (either by crossing or as drops or service conductors), the assumed loads for each line to be applied to the common structure shall be determined using the strongest grade called for in Table 27, 28, or 29. The longitudinal loads of the additional line(s) shall be assumed to act in each direction across the main line.

7.9.2
The load on the common structure shall be calculated by taking the vector sum of the forces due to the loads on each line calculated in accordance with Clauses 7.4 to 7.8, using the load factors for the type of load being considered.

7.9.3
In the additional line(s), where conductors, messengers, cables, or guys have balanced tensions at the common structure, the assumed longitudinal load for such conductors, messengers, cables, or guys may be reduced to 50% of the load specified in Clause 7.8.2.

7.9.4
The wind shall be assumed to act in directions producing the maximum stress in each line for each type of load considered.

7.9.5
The loads on one line shall not be reduced as a result of loads on another line.

8 Strength of supporting systems according to deterministic design methods

8.1 General

8.1.1
Clause 8 specifies the strength requirements for supply and communication lines designed to withstand the loads specified in Clause 7. The strength requirements in Clause 8 shall apply to all grades of construction unless otherwise specified.

8.1.2
The longitudinal strength requirements specified in Clause 8 generally apply only to the structure immediately adjacent to a crossing, or at the ends of a proximity or joint-use section. The requirements specified in Clause 8 for transverse strength and strength at angles generally apply to each of the structures within the crossing, proximity, or joint-use section.

8.1.3
Deformation, deflection, or displacement of parts of the structure can sometimes change the effects of the assumed loads. When calculating stresses, no allowances shall be made for such deformation, deflection, or displacement of supporting structures (including poles, towers, guys, crossarms, pins, posts, conductor fastenings, and suspension insulators), except for wood poles, in accordance with Table E.1, or where the methods used to evaluate the deformation, deflection, or displacement have been mutually agreed upon by the parties involved.

Note: *Non-linear analysis, including stability (buckling) check (see Table 31) is the method of analysis that should be used.*

8.2 Materials

8.2.1

Materials, including those used in foundations and settings, shall be able to withstand and maintain safely the loads specified in Clause 7.

8.2.2

Tie wires and fastenings shall have no sharp edges at points of contact with conductors and shall be applied such that they do not damage line conductors. Tie wires shall be made of a material that does not cause corrosion. The side pull of the conductor due to a change in the direction of the conductors shall be against the insulator rather than the tie wire.

8.2.3

Messenger clamps and messenger fastenings shall be of sufficient strength to withstand the assumed loads for messengers specified in Clauses 7.4 to 7.9.

8.3 Strength of supports

8.3.1 Structures — All grades

8.3.1.1

Poles, structures, and towers shall be capable of withstanding the assumed loads specified in Clauses 7.4 to 7.9 and any unbalance due to uneven spans or uplift under the wire loads specified in Clause 7.3.1 for new structures and those where additional attachments are made.

8.3.1.2

The strength requirements for poles and towers may be met by the structures alone or with the aid of guys or braces.

8.3.1.3

When the strength of a wood pole structure has deteriorated to 60% of the required design capacity, the structure shall be reinforced or replaced.

8.3.2 Vertical pull due to changes in elevation

The change in elevation of the conductors of a line approaching a crossing shall be such that there will be no uplift on the pins, posts, insulators, or ties on the crossing structures or on the immediately adjacent structures, unless special precautions are taken to ensure that the conductors, insulators, pins, or posts will not become detached from the supports and that vertical displacement of the structures themselves will not occur.

8.3.3 Spliced wood poles

Spliced wood poles may be used, provided that recognized methods of splicing are employed and that the splice and the whole assembly meet the strength requirements for wood poles.

8.3.4 Stub-reinforced poles

Stub-reinforced poles may be used, provided that the above-ground section of the pole is sound and free from defects that would materially affect its strength, and provided that the reinforcement method used ensures that the whole assembly meets the strength requirements for wood poles.

8.3.5 Pole top supports and pole top pins

Pole top supports and pole top pins and posts may be used, provided that they do not impair the strength of the pole. They shall be considered an integral part of the structure and shall be subject to the same load factors as the pole itself.

8.3.6 Pole mounts

Pole mounts and their anchorages shall be of sufficient strength to withstand the load transferred by the pole under the loads specified in Clause 7.

8.3.7 Special wood structures

Wood structures such as H-frame structures shall have a transverse or longitudinal strength corresponding to the number of poles used. Where fully braced, poles shall be in either tension or compression and, where suitable foundations are provided to prevent their overturning, such structures may be considered unit-trussed structures, and the additional strength provided may be used in meeting transverse strength requirements.

8.3.8 Wood poles

8.3.8.1

Wood poles shall comply with CAN/CSA-O15. Poles not covered by CSA Standards but having adequate strength and durability may be used when agreed to by the parties involved. Damage and failure limits of wood poles are specified in Table A.4.

8.3.8.2

Where Grade 1 construction is required, no wood pole shall be weaker than CSA Class 6, except that CSA Class 7 may be used to support a single supply conductor or communication drop wire, provided that the requirements of Grade 1 construction are met.

Note: *Where wood poles are used, they should be treated with a preservative in accordance with applicable CSA Standards.*

8.3.9 Concrete poles

Concrete poles shall be in accordance with applicable CSA Standards and shall not be weaker than the equivalent of a CSA Class 6 wood pole where Grade 1 construction is required. Damage and failure limits of concrete poles are specified in Table A.4.

8.3.10 Metal poles, metal towers, and metal supports

8.3.10.1

In the design of metal poles, metal towers, and metal supports, the "load factor" specified in Table 31 shall be interpreted such that the completed structure will support, with only negligible deformation of component parts (see Table A.4), the assumed loads to which it will be subjected, as specified in Clauses 7.3 to 7.9.

8.3.10.2

The absence of a permanent set in the structure indicates that no part has been stressed beyond the yield point. Allowance should be made for bolt slip and anchor consolidation. Metal structures fully supported by guys shall meet the requirements for self-supporting structures, and such guys shall be in accordance with the minimum load factors specified in Table 32.

8.3.11 Foundations and settings

Foundations and settings shall be of sufficient strength to withstand the load transferred by the pole or structure under the assumed loads specified in Clause 7. Where necessary, protection against washouts or debris slides shall be provided.

8.3.12 Fibre-reinforced composite poles

8.3.12.1

Fibre-reinforced composite poles shall comply with the applicable requirements of ASCE Manual 104.

8.3.12.2

In the design of fibre-reinforced composite poles, the "minimum load factor" of Table 31 shall be interpreted such that the completed structure will support the assumed loads to which it will be subjected, as specified in Clauses 7.3 to 7.9. Fibre-reinforced composite poles may use the minimum load factors for steel poles, provided that the manufacturer proves through testing that the fibre-reinforced composite poles meet or exceed the minimum 5th percentile strength (i.e., the 5% lower exclusion limit). In the event that the manufacturer cannot meet the 5th percentile strength requirements, the fibre-reinforced composite poles shall use as default values the minimum load factors for wood poles.

8.3.12.3

Fibre-reinforced composite structures fully supported by guys shall meet the requirements for self-supporting structures. Such guys shall meet the load factors specified in Table 32. Damage and failure limits of fibre-reinforced composite poles are specified in Table A.4.

8.3.12.4

To verify the adequacy of composite poles to meet the required loads (i.e., working loads multiplied by the appropriate load factors), the manufacturer shall have and make available actual test data from full-scale bending tests of similar composite poles, conducted in accordance with ASTM D1036. Additional bending or other verification tests may be requested by the purchaser.

8.4 Guys, guy assemblies, and braces

8.4.1 Application of guys

8.4.1.1

Guys may be used with structures when needed to provide necessary strength. Where poles or other flexible supports are used, the required transverse and longitudinal strength shall be achieved, where practicable, by the use of side and head guys. Guys and their fastenings shall meet applicable CSA Standards. Those guys and fastenings that are not covered by CSA Standards but that have adequate strength and durability may be used when agreed to by the parties involved.

8.4.1.2

The guy shall be attached as close as practicable to the centre of the load that the guy is designed to sustain.

8.4.1.3

Pole braces should not be used as substitutes for anchor guys. However, where they offer advantages, they shall be of the same class, or stronger, as the poles with which they are associated.

8.4.1.4

To avoid abrasion, guys shall not be placed or maintained in contact with other guys, stubs, or anchors, nor maintained in contact with metallic covered cables, suspension wires, or overhead ground wires, except where the guys have been attached to the same point and protected at the point of contact.

8.4.1.5
Wood, concrete, fibre-reinforced composite, and metal poles deflect appreciably when horizontal loads are applied near the top thereof. Consequently, when such a structure is guyed, the guy shall be considered as taking the entire load in the direction in which it acts, with the structure serving only as a strut.

8.4.2 Installation of anchorages

8.4.2.1
Anchor rods shall be installed such that they are in line with the pull of the attached guy when under load, except that in rock or concrete the rod may be at right angles to such pull.

8.4.2.2
Guy strand shall be attached to the eye of the anchor rod above ground.

8.4.2.3
Where direct attachment to anchor rods is not practicable, guys may be attached to stubs or poles that are themselves properly guyed, or to other secure structures. Guys shall not be attached to trees.

8.4.3 Side-guyed structures — Grades 1, 2, and 3
Where conditions make it impracticable to side-guy a crossing or other transversely weak structure in order to meet transverse strength requirements, these requirements may be met by the use of special structures or by side-guying the line at each side of, and as near as practicable to, the crossing or transversely weak structure, provided that
(a) the distance between the side-guyed structures does not exceed 250 m or two spans (where the distance of two spans exceeds 250 m);
(b) the side-guyed structures are capable of withstanding the calculated transverse load due to wind on the supporting structures and ice-covered conductors in the entire section between the side-guyed structures;
(c) the line between the side-guyed structures is substantially straight; and
(d) the entire section between the transversely strong structures complies with the required grade of construction, except for the transverse strength of intermediate poles or towers.

8.4.4 Head-guyed structures

8.4.4.1 General
Longitudinal strength requirements shall be met by placing structures of the required strength at the crossing or at the ends of proximity or joint-use sections. Where this is impracticable, the alternatives specified in Clauses 8.4.4.2 and 8.4.4.3 may be adopted, using the loads specified in Clauses 7.4 to 7.9.

8.4.4.2 Grade 1

8.4.4.2.1
For conductors, messengers, cables, ground wires, and other such items with an ultimate strength greater than 12.4 kN (except at terminations), structures of the required longitudinal strength may be located one or more span lengths away from the crossing structure or end of proximity or joint-use sections.

The line between the longitudinally strong structures shall be approximately straight or suitably guyed and shall meet the requirements for transverse strength. This requirement shall not apply to terminations.

8.4.4.2.2
For conductors, messengers, cables, and ground wires with an ultimate strength less than 12.4 kN, and for terminations where it is impracticable to guy the crossing structure or the structure at the end of the proximity or joint-use section, strength requirements may be met by head-guying the line as near as

practicable to, but at a distance not exceeding 150 m from, the nearest crossing pole or structure at the end of the proximity or joint-use section, provided that the line is approximately straight and that a steel wire strand of strength equal to that of the head guy is run between the guyed poles. The strand shall be attached to the guyed poles at the point at which the head guys are attached and shall be secured to every pole between the guyed poles.

8.4.4.3 Grades 2 and 3

The requirements of Clause 8.4.4.2 shall apply to Grades 2 and 3 at terminations or at angles using dead-end construction.

8.4.5 Longitudinal guying requirements for combinations of messenger cable and wire at crossings

For lines carrying both open wire and cable, the cable messenger may be used to provide the necessary longitudinal strength, provided that

(a) the messenger is dead-ended and guyed in accordance with the crossing requirements;
(b) messenger fastenings at crossing poles are capable of transmitting the assumed loads from the pole to the messenger;
(c) the assumed load due to the open wire plus the maximum tension due to the cable, as specified in Clause 7, does not exceed 60% of the ultimate strength of the strand, and the messenger has an ultimate strength not less than 26 kN; and
(d) the pole is capable of withstanding the assumed loads imposed at the point of messenger attachment, using the appropriate load factor.

8.5 Crossarms, pins, posts, and fastenings — Grades 1, 2, and 3

8.5.1 Strength

Crossarms, crossarm assemblies, pins, posts, and fastenings shall have sufficient strength to withstand the assumed loads specified in Clauses 7.4 to 7.9.

8.5.2 Strength of crossarms

Crossarms shall meet the requirements of the applicable CSA Standard. Crossarms shall be attached to wood, concrete, fibre-reinforced composite, or metal structures by devices of adequate strength to support the specified loads. Where through-bolts are used, they shall be not less than 15 mm in diameter. Lag screws shall not be used.

8.6 Strength of insulators

8.6.1 Pin-type and post-type insulators

Pin-type and post-type insulators shall withstand the stress incurred when the conductor is subjected to the loads specified in Clauses 7.4 to 7.9.

8.6.2 Suspension-type insulators

8.6.2.1

Suspension-type insulators that are normally in the vertical position shall withstand, without exceeding 1/2 of their rated ultimate strength, the resultant vertical and transverse loads.

8.6.2.2

Suspension-type insulators in the strain position shall withstand, without exceeding 1/2 of their ultimate strength, the tension that occurs when the conductor is subjected to the loads specified.

8.7 Supply conductors, supporting conductors, and messengers

8.7.1 Materials
Conductor or messenger materials shall meet the requirements of applicable CSA Standards.

8.7.2 Minimum breaking strength — Grade 1
For Grade 1 construction supply conductors, supporting conductors and messengers shall have a minimum breaking strength not less than 12.4 kN.

8.7.3 Wire tension limits

8.7.3.1 Reliability-based design cases where limit loads are used
Note: *Limit loads are loads inclusive of all load factors.*

8.7.3.1.1
The initial tension limit at average temperatures during the coldest month (January) should not exceed a catenary parameter of 2000 m for single conductor spans properly equipped with vibration dampers. In the case of bundled conductors, the catenary parameter may be increased to 2200 m.
Note: *This limit does not apply to special conductors such as self-damping conductors where different limits may be used in accordance with past experience and appropriate studies.*

8.7.3.1.2
For economical reasons, consideration may be given to reducing the limit of 2000 m when spans are less than 400 m, because such reduction will not greatly affect the conductor sag, but will provide additional safety for fatigue damage to conductors due to aeolian vibration and will reduce loads on angle structures. Reductions of the catenary parameter of 2000 m that should be used are specified in Table 33.

8.7.3.1.3
The final tension limit after creep or permanent stretch due to ice and wind loads should not exceed 70 to 80% UTS.
Note: *A value of 75% UTS may be used and has been applied to many Canadian lines.*

8.7.3.2 Deterministic design

8.7.3.2.1
Conductor tensions under deterministic ice and wind loads shall not exceed 60% UTS of the conductor.

8.7.3.2.2
The initial conductor tension limit shall not exceed the values specified for reliability-based design. For spans of 75 m or less in length, which are typical for distribution lines, consideration may be given to further reducing the initial tension limits because it lowers the risk of vibration problems and reduces loads on angle structures, while having insignificant impact on conductor sag.

8.8 Lightning protection wires

8.8.1 General
Lightning protection wires that run parallel to line conductors shall comply with Clause 8.7.2 where Grade 1 construction is required, except that galvanized steel wire strand shall comply with Clause 8.8.2.

8.8.2 Galvanized steel wire strand

Galvanized steel wire strand shall
(a) comply with CAN/CSA-G12;
(b) have a minimum diameter of 6.35 mm; and
(c) not exceed the maximum allowable tensions specified in Table 34.

8.9 Trolley contact conductors

To allow for wear, trolley contact conductors shall be not smaller than No. 1/0 AWG when made of hard-drawn copper, or No. 4 AWG when made of silicon bronze, and shall be replaced when they have deteriorated to 60% of their original breaking strength.

8.10 Supply cables — Grades 1, 2, and 3

There are no strength requirements for supply cables supported by messengers or by supporting conductors.

8.11 Communication conductors and cables — Grades 1, 2, and 3

8.11.1 Grade 3

There are no special requirements for size and strength of communication conductors where Grade 3 construction is used.

8.11.2 Material — Grades 1 and 2

Bare conductors shall be of a material or combination of materials that has a resistance to corrosion at least equivalent to that of steel line wire having a zinc coating of at least 0.25 kg/m^2.

8.11.3 Sags and tensions

Sags of all open-wire communication conductors shall be such that, under the assumed loading conditions for the applicable area, the tension of the conductor is not more than 60% of its ultimate strength. In addition, the tension at 15 °C, without an external load, shall not exceed 20% of the conductor's ultimate rated tensile strength.

8.11.4 Communication conductors crossing over supply lines

Open-wire communication conductors crossing over open-wire supply conductors shall meet the size and strength requirements of supply conductors of the required grade. See Clauses 8.7 to 8.9.

8.12 Paired communication conductors — Grades 1 and 2

8.12.1 Paired conductors supported by messengers

Where paired conductors cross over supply conductors of more than 750 V line-to-ground, they shall be supported by a messenger that meets the requirements of Clause 8.13.2.

8.12.2 Paired conductors not supported by messengers — Grades 1 and 2

8.12.2.1

Paired conductors without supporting messengers shall not be used
(a) in proximity to or crossing over supply lines greater than 750 V line-to-ground; or
(b) in spans longer than 30 m in heavy and severe loading areas, or spans longer than 38 m in medium loading areas.

8.12.2.2
When paired conductors are used on Grade 1 and 2 construction, each conductor shall have a strength greater than or equal to 750 N. Alternatively, where an individual strength is less than 750 N, the overall strength of the assembly shall be not less than 2225 N.

8.13 Communication cables and messengers

8.13.1 Communication cables
There are no strength requirements for communication cables supported by messengers.

8.13.2 Messengers

8.13.2.1 Maximum allowable tension — Grades 1, 2, and 3
Messengers shall not be stressed beyond 60% of their ultimate strength under the loads specified in Clause 7.3.

8.13.2.2 Size — Grade 1
At railway crossings or in proximity to railways, messengers supporting cables shall have a breaking strength not less than 12.4 kN. At railway crossings that are in joint use with, or in proximity to, supply conductors greater than 750 V line-to-ground, messengers shall have a breaking strength not less than 12.4 kN. At railways crossings or in proximity to railways, paired conductors supported by messengers shall have a breaking strength not less than 5.3 kN.

8.13.2.3 Material — Grades 1 and 2
All steel stranded messengers shall meet the minimum requirements for zinc-coated steel strand specified in CAN/CSA-G12. Steel messengers consisting of a single wire shall meet the requirements for individual zinc-coated wires, before stranding, specified in CAN/CSA-G12. Messenger materials other than zinc-coated steel may be used, provided that these materials have a corrosion resistance at least equivalent to that required for zinc-coated steel of similar size and strength.

8.14 Supply and communications — Messenger clamps and fastenings: Grades 1, 2, and 3
Messenger clamps and fastenings shall meet the requirements of Clause 8.2.

8.15 Supply and communications — Cable attachments to suspension strand: Grades 1, 2, and 3

8.15.1 General
Cable attachments shall be spaced so that they will safely support the cable and prevent appreciable sagging of the cable.

8.15.2 Cable attachments at railway crossings
At railway crossings where lashing is employed, the cable shall be double-lashed using stainless steel lashing wire at least 1.14 mm in diameter.

8.16 Splices at crossings — Grades 1

8.16.1
Splices shall not be made in a crossing span except as specified in Clause 8.16.2, and should not be made in the adjoining spans. If making a splice in the adjoining span is unavoidable, the splice shall be of a type that resists corrosion and withstands the assumed loads specified in Clause 7.3.

8.16.2
Full-tension compression splices may be used over crossings to effect repair or maintenance.

8.17 In-span taps at crossings — Grades 1 and 2

8.17.1 Supply conductors greater than 750 V
The use of in-span taps in railway crossing spans shall be avoided. Where their use is unavoidable, they shall withstand the assumed loads specified in Clause 7.3 and, except as allowed otherwise by Clause 8.17, they shall be installed using compression-type connections. Under no circumstances shall a tap be installed using bolted connections, except that bolted stirrups with hot line taps may be used where unavoidable. The restrictions of this Clause shall not apply to the conductor tail at dead ends or to taps in other spans.

8.17.2 Supply conductors of 0 to 750 V and communication conductors
In-span taps shall not be used in Grade 1 or 2 crossings unless they are attached to the conductor tail at dead ends.

8.18 Supply-line insulators

8.18.1 General
Insulators that operate on supply circuits greater than 750 V line-to-ground shall
(a) meet the requirements of
  (i) CSA C411.1, CAN/CSA-C411.4, CSA C411.5, CSA C411.6, and CSA C411.7; or
  (ii) ANSI C29.1, ANSI C29.11, ANSI C29.12, and ANSI C29.13; or
(b) be of another insulating material that provides comparable mechanical and electrical performance.

8.18.2 Selection of insulators
When selecting insulators to be used for line, consideration shall be given to the prevailing level of contamination. See IEC/TS 60815-1, IEC/TS 60815-2, and IEC/TS 60815-3 for guidance on the selection of insulators in polluted conditions.

8.18.3 Protection against arcing
When installing insulators and conductors, good practice shall be used to prevent, as much as is possible, an arc from forming, including those arcs due to weakening or burning of any parts of the structures, insulators, or conductors.

9 Grounding methods for supply systems less than or equal to 22 kV and communications facilities

9.1 Supply systems less than or equal to 22 kV

9.1.1 Conductors

9.1.1.1 Conductor composition
The grounding conductor shall be made of copper or another metal or combination of metals that will not corrode excessively during the expected service life of the conductor under existing conditions. Where joints are unavoidable, they shall be made and maintained such that they do not materially increase the resistance of the grounding conductor and they shall have appropriate mechanical and corrosion-resistant characteristics.

9.1.1.2 System grounding conductors

System grounding conductors, exclusive of grounds at individual services, shall have a short-time ampacity adequate for the fault current that can flow in the grounding conductors for the operating time of the system-protective device. Where the fault current cannot be readily determined, continuous ampacity of the grounding conductor or conductors shall be not less than the full-load continuous current of the supply transformer or other source of supply. In no case shall the ampacity of the grounding conductor be less than that of No. 4 AWG copper.

Notes:

(1) *For bare grounding conductors, the short-time ampacity is the current that the conductor can carry for the applicable time without melting or affecting the design characteristics of the conductor.*

(2) *For insulated grounding conductors, the short-time ampacity is the current that the conductor can carry for the applicable time without affecting the design characteristics of the insulation.*

(3) *Where grounding conductors at one location are paralleled, the increased total current capacity may be considered.*

9.1.2 Ground resistance requirements

9.1.2.1 Multi-grounded systems

9.1.2.1.1

The neutral shall be of sufficient size and ampacity for the intended use and shall be connected to a ground electrode at each piece of active electrical equipment and to a sufficient number of additional ground electrodes (not including grounds at consumers' services) to prevent electric shock hazards caused by the buildup of excessive steady-state neutral-to-earth voltage.

Note: *Multi-grounded neutral systems that extend over a substantial distance depend more on the multiplicity of grounding electrodes than on the resistance-to-ground of one individual electrode. Therefore, no specific values are prescribed for the resistance of individual electrodes.*

Where practicable, the resistance of the interconnected neutral system shall not exceed 6 Ω.

9.1.2.1.2

Where there are isolated multi-grounded neutral systems that are bridged by telecommunication circuits, a continuous multi-grounded neutral system complying with Clause 9.1.2.1.1 shall be provided for single-phase and three-phase grounded systems supplied from the same three-phase feeder, unless

(a) the distance between the multi-grounded neutral systems prevents electrical hazards from ground current flow on communication equipment; or

(b) other methods are used to prevent electrical hazards from ground current flow on communication equipment.

9.1.2.2 Earth return systems

9.1.2.2.1

When designing the grounding of an earth return system, the following factors shall be considered:

(a) soil resistivity;

(b) step and touch potential under steady-state and fault conditions;

(c) magnitude of fault currents; and

(d) frequency and number of ground electrodes installed.

9.1.2.2.2

Where earth return systems are used, the following criteria shall be met:

(a) The resistance-to-ground of any individual electrode shall not exceed 25 Ω and the resistance of the grounding installation without interconnection to the consumer's service grounding system shall not exceed 6 Ω. Where these readings cannot be achieved, an additional two electrodes connected in parallel or two deep-driven electrodes, shall be used. Where the required readings cannot be achieved with the two additional electrodes, the grounding system shall be extended into a multi-grounded system until the 6 Ω interconnected reading can be achieved.

(b) Measures shall be taken to prevent electric shock hazard to persons caused by the buildup of steady-state neutral-to-earth voltage.
(c) The grounding installation shall consist of a redundant grounding system with ground electrodes separated by a distance greater than their depth that are located on different sides of the pole or on separate poles.
(d) The transformer primary neutral terminal, transformer case, lightning arrester, grounded conductor, and secondary neutral terminal shall
   (i) be connected to the ground electrode using the appropriate ground conductor; or
   (ii) have a suitable warning label or markings on the pole where primary and secondary neutrals are not connected.

9.1.3 Ground electrodes and connections

9.1.3.1

Ground electrodes, ground electrode couplers, and connections to ground electrodes shall
(a) have sufficient ampacity to safely conduct the electric utility system fault current and any steady-state ground current that might flow on the electric utility grounding system;
(b) be corrosion resistant;
(c) be enduring; and
(d) be manufactured in accordance with CSA C22.2 No. 41, where applicable.

9.1.3.2

Where practicable, ground electrodes shall be installed such that they extend below the frost level.

9.1.3.3

Where used, rod-type ground electrodes shall be installed such that
(a) the top ends of the ground electrodes are a minimum distance of 300 mm below final grade level; and
(b) the horizontal distance between ground electrodes is greater than or equal to their length.

9.1.4 Mechanical protection of supply grounding conductors

Grounding conductors of supply systems shall be protected by a covering that provides suitable mechanical protection from at least 0.3 m below to at least 2.0 m above grade.

The minimum distance above grade level for the protective covering on grounding conductors of gang-operated switches may be reduced to the height of the operating handle.

Where metallic conduit is used to protect ground and neutral conductors on poles or structures, the metallic conduit shall be grounded.

9.1.5 Non-conducting covering for supply grounding conductors

On joint-use poles where the communication facility is not bonded to the supply ground, supply grounding conductors shall be covered with a suitable non-conductive protective covering. The non-conducting covering shall extend up to the communication plant. This covering need not be applied to supply grounding conductors on metal structures.

Note: *The non-conducting covering may also be used to provide the mechanical protection specified in Clause 9.1.4.*

9.1.6 Interconnecting ground electrodes and grids

Ground conductors used to interconnect ground electrodes or form ground grids underground shall be installed a minimum distance of 300 mm below grade.

9.1.7 Grounding metal and concrete poles

Metal poles or the reinforcing metal of concrete poles, where such poles carry supply-line conductors or are in contact with metal-sheathed supply cable or the metal cases of supply equipment, shall be effectively grounded, guarded, or isolated.

9.1.8 Non-current-carrying items of supply and communication equipment

Items such as metal conduit, cable sheaths, metal lamp posts, frames, cases, and hangers of equipment shall be effectively grounded where
(a) they might become energized at more than 750 V;
(b) they are less than 2.5 m above the ground or accessible surface; or
(c) they are not guarded from accidental contact by anyone other than qualified persons.

9.1.9 Grounding lightning arresters

Lightning discharge currents contain high-frequency components that produce large voltage gradients on grounding conductors. The grounding connection between the arrester and the frames of equipment being protected shall be as short, straight, and free from sharp bends as practical in order to
(a) avoid hazards due to flashover to nearby objects;
(b) permit effective operation of the lightning arrester; and
(c) minimize the impedance of the connection.

The grounding conductor shall have adequate short-time ampacity to carry the excess current caused by or following a surge. Individual arrester grounding conductors shall be no smaller than No. 6 AWG copper or an electrical equivalent.

9.1.10 Grounding pole-mounted equipment

For equipment connected in a grounded-wye configuration, the neutral point(s) of pole-mounted transformers, capacitors, or regulators shall be grounded with a ground conductor connected to a ground electrode.

9.1.11 Gang-operated switches

The metallic frame and operating mechanism, including control boxes of gang-operated switches, shall be grounded with a ground conductor connected to a ground electrode or ground grid. Grounding of the control rod is not required where the control rod is isolated with a fully rated insulator and the switch frame above the insulator is bonded to the system neutral. In this case, any ground on the pole shall not extend below the insulator. Grounding is not required for hook-stick-operated gang switches.

9.1.12 Ground interconnections

Where different systems serve the same customer, the grounds of the different systems shall be bonded. A single grounding conductor may be used for both supply and communication grounding, provided that the ground connection is of sufficiently low impedance and of sufficient current-carrying capacity to prevent the buildup of voltages that can result in a hazard to persons or equipment.

9.1.13 Grounding of riser pipes and guards

Exposed metal riser pipes and guards in contact with supply cables shall be grounded.

9.1.14 Grounding conductors on joint-use structures

9.1.14.1 Grounding of supply attachments on joint-use structures

With the exception of the attachments specified in Clause 9.1.14.2, where conductors, apparatus, or equipment such as transformer casings or luminaire brackets are constructed to the clearance and separation values for effectively grounded systems as specified in Clause 5.10, each grounding conductor and all connection points directly associated with such apparatus or equipment shall, in the case of wood structures, be constructed such that they are visible to a qualified person standing on the ground. As far as practicable, the requirements of this Clause shall also apply to metal, fibre-reinforced composite, and concrete structures.

9.1.14.2 Grounding of consumer service and equipment on joint-use structures

Where outdoor electrical equipment that is approved in accordance with the *Canadian Electrical Code, Part I*, manufactured in accordance with applicable Standards of the *Canadian Electrical Code, Part II*, and connected to a consumer's service at 750 V or less, is installed in accordance with the clearance and separation values for effectively grounded systems as specified in Clause 5.10, the attachments and service shall meet the requirements of the *Canadian Electrical Code, Part I*. The installation shall have a means of disconnect that is approved in accordance with the *Canadian Electrical Code, Part I* and located such that it can be operated safely by communications workers.

9.2 Grounding and bonding of communications facilities

9.2.1 General

9.2.1.1 Grounding conductor

The grounding conductor shall be made of copper or another metal or combination of metals that will not corrode excessively during the expected service life of the conductor under existing conditions. Where joints are unavoidable, they shall be made and maintained such that they do not materially increase the resistance of the grounding conductor and they shall have appropriate mechanical and corrosion-resistant characteristics.

9.2.1.2 Grounding and bonding conductor size

For communications-only lines, the grounding conductor shall be a minimum of No. 6 AWG insulated wire. For joint-use and non-joint-use poles, the bonding conductor shall be a minimum of No. 6 AWG insulated wire.

9.2.1.3 Ground electrodes

Ground electrodes shall
(a) be corrosion resistant;
(b) be enduring;
(c) be manufactured in accordance with CSA C22.2 No. 41, where applicable; and
(d) extend below the frost level, where practical.

9.2.1.4 Ground connections

Ground connections used on grounding systems for communications systems shall comply with CSA C22.2 No. 41, as applicable.

9.2.2 Grounding and bonding intervals — Aerial non-joint use

9.2.2.1

On communication-only lines, the support strand shall be grounded at each end of the pole line and at intervals not exceeding 1200 m. No point on the cable sheath shall be further than 600 m from a ground.

The cable sheath bonding interval shall not exceed
(a) 300 m for copper cables; and
(b) 1500 m for fibre cables.

9.2.2.2

Support strands that cross over one another at right angles shall be bonded at the point of intersection. Support strand shall be bonded to guys at corners.

9.2.2.3

Bonds shall be made as close as possible to dead-end poles on cable laterals.

9.2.2.4
A bond to the multi-grounded neutral shall be placed at all joint-use crossover poles.

9.2.2.5
Where mechanical protection is installed on the vertical ground conductor, it shall be provided by means of a protective covering that runs from at least 2.0 m above grade to at least 300 mm below grade.

9.2.3 Grounding and bonding intervals — Aerial joint use: copper cables

9.2.3.1
Grounding and bonding intervals of communications plant (copper cables) shall comply with CSA C22.3 No. 5.1.

9.2.3.2
Support strands shall be bonded across poles with double dead ends (e.g., at corners). Bonds shall be made as close as possible to dead-end poles on cable laterals.

9.2.3.3
Where two or more suspension strands are located on the same pole line, they shall be bonded together at 300 m intervals. Where the strands are supported on the same suspension clamp, the clamp shall function as the bond.

9.2.4 Grounding and bonding intervals — Aerial joint use: fibre cables

9.2.4.1
Grounding and bonding intervals of communications plant (fibre cables) shall comply with CSA C22.3 No. 5.1.

9.2.4.2
On joint-use poles, the sheath bonding interval for fibre cables shall be 1500 m (i.e., no point on the sheath shall be farther than 750 m from a sheath bond).

9.2.4.3
Metallic strength members in fibre cables and any armouring shall be bonded to the cable sheath at each splice.

9.2.5 Grounding and bonding in the zone of influence of a substation
Grounding and bonding of communications facilities in the zone of influence of a substation shall comply with IEEE 487.

9.2.6 Bonding and grounding with joint use on earth return and ungrounded (delta) supply systems

9.2.6.1
There should be no joint use with earth return and ungrounded systems. If joint use with either of these supply systems is the only option, CSA C22.3 No. 5.1 should be consulted for special engineering considerations.

9.2.6.2
Joint use with earth return or ungrounded systems may be considered where ADSS fibre optic cable is used.

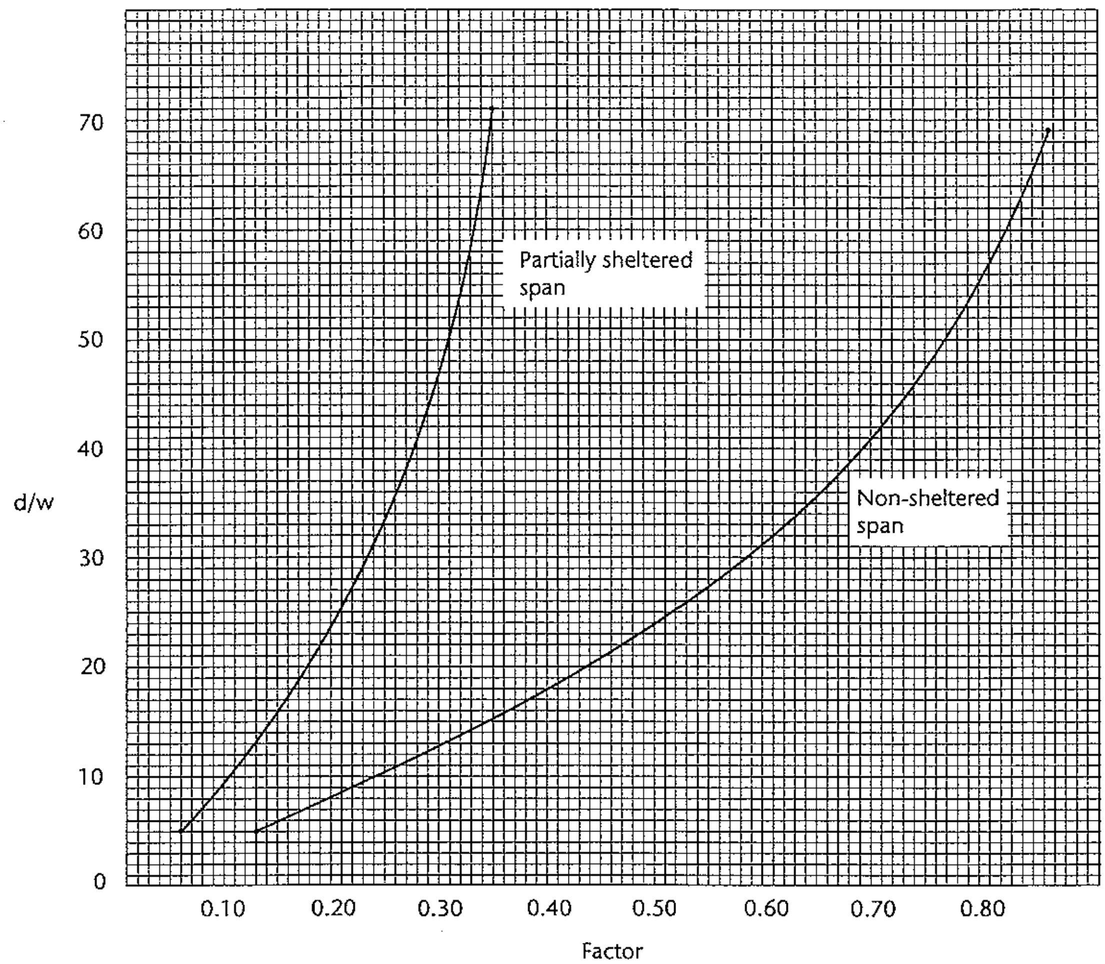
10 Reliability-based design method

Supply and communication lines shall be designed using the deterministic design method or the reliability-based design method. Clauses 7 and 8 outline the deterministic method of calculating the loads to be applied to the design of the line and the strength of the structures needed to support these loads safely. The reliability-based design method is covered in CSA C22.3 No. 60826.

The reliability-based method should be used for supply lines greater than 70 kV phase-to-phase, in areas where significant amounts of meteorological data are readily available. This method may also be used for lines designed for specific climatic loads in accordance with previous experience or calibration with existing lines having a long history of satisfactory performance.

Table 1
Wire and conductor swing for horizontal design clearance

(See Clauses 5.2.7, A.5.2.7, and A.5.8.2.)



Notes:

(1) *Horizontal deviation = factor × conductor sag*
d = diameter of conductor, mm
w = mass per unit length, kg/m

(2) *A partially sheltered span is one that is protected (from swinging transversely in the wind) by objects such as buildings whose height is greater than or equal to wire or conductor height and that are within an effective distance (e.g., 30 m) of the wire or conductor. Trees are not generally considered to provide shelter.*

Table 2
Minimum vertical design clearances above ground or rails, ac
(See Clauses 5.3.1.1, 5.7.4.1, and A.5.3.1 and Tables 4, 9, and 11.)

Location of wires or conductors	Minimum vertical clearance above ground or rails, m											
	Guys; messengers; communication, span, and lightning protection wires; communication cables	Trolley contact conductors and associated span wires; trolley feeders 0–750 V when paralleled by trolley contact conductors	Open supply conductors and service conductors, ac*, kV									
			0–0.75	> 0.75 ≤ 22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 120	> 120 ≤ 150	> 150 ≤ 200	220 (360)	318 (500)	442 (735)
	Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX	Col. X	Col. XI	Col. XII
Over land likely to be travelled by road vehicles (including highways, streets, lanes, alleys, and driveways other than those leading to residences or residence garages)	4.42	4.42	4.42	4.75	5.2	5.5	5.8	6.1	6.6	10.2†	15.4†	20.4†
Over the right-of-way of underground pipelines	4.42	4.42	4.42	4.75	5.2	5.5	5.8	6.1	6.6	6.8	9.9†	13.2†
Alongside land likely to be travelled by road vehicles§ or within the limits (with no overhang) of streets and highways	4.42‡	4.42	4.42	4.75	5.2	5.5	5.8	6.1	6.6	10.2†	15.4†	20.4†

(Continued)

Table 2 (Continued)

Location of wires or conductors	Minimum vertical clearance above ground or rails, m											
	Guys; messengers; communication, span, and lightning protection wires; communication cables	Trolley contact conductors and associated span wires; trolley feeders 0–750 V when paralleled by trolley contact conductors	Open supply conductors and service conductors, ac*, kV (See Notes 1–3.)									
			0–0.75	> 0.75 ≤ 22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 120	> 120 ≤ 150	> 150 ≤ 200	220 (360)	318 (500)	442 (735)
	Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX	Col. X	Col. XI	Col. XII
Over or alongside farmland likely to be travelled by vehicles§	4.42**	N/A	4.42	4.75	5.2	5.5	5.8	6.1	6.6	6.8	9.9†	13.2†
Over driveways to residences and residence garages	3.7	N/A	3.7	4.75	5.2	5.5	5.8	6.1	6.6	10.2†	15.4†	20.4†
Alongside roads and highways in areas unlikely to be travelled by road vehicles (with no overhang) and within 1.5 m of the limit of the road right-of-way††	3.0	N/A	3.4	4.15	4.6	4.9	5.2	5.5	6.0	6.2	7.2	8.4
Over walkways or ground normally accessible only to pedestrians, snowmobiles, and personal-use all-terrain vehicles‡‡	2.5	N/A	3.1	3.4	3.7	4.0	4.3	4.6	5.1	5.3	6.3	7.5

(Continued)

Table 2 (Continued)

Location of wires or conductors	Minimum vertical clearance above ground or rails, m											
	Guys; messengers; communication, span, and lightning protection wires; communication cables	Trolley contact conductors and associated span wires; trolley feeders 0–750 V when paralleled by trolley contact conductors	Open supply conductors and service conductors, ac*, kV									
			0–0.75	> 0.75 ≤ 22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 120	> 120 ≤ 150	> 150 ≤ 200	220 (360)	318 (500)	442 (735)
	Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX	Col. X	Col. XI	Col. XII
Above top of rail at railway crossings§§	7.3	6.7	7.3	7.6	8.1	8.4	8.7	9.0	9.5	9.7	10.7	11.9

*For dc voltages below 750 V, use Columns II and III.

†Specifies clearances based on induced electrostatic steady-state currents. Other values may be used based on other line configurations, voltages, or assumptions regarding vehicle length and orientation. (See Clause A.5.3.1.) Provision of other mitigative measures such as shielding can reduce these clearances.

‡Where communication wires or communication cables run along alleys, this clearance may be reduced to 4 m.

§Where a line runs parallel to land accessible to vehicles but is over land not requiring clearance for vehicles, the wire can swing out over the area accessible to vehicles or, at voltages over 200 kV, vehicles can be subjected to a hazard from induced voltages. These vertical clearances apply where the conductor (in the swing condition, where specified) is over, or within the following horizontal distances from the edge of, land accessible to vehicles:
(a) 0 m for wires in Columns I to V;
(b) 1 m for wires in Column VI;
(c) 1.4 m for wires in Column VII;
(d) 1.7 m for wires in Column VIII;
(e) 1.7 m + 0.01 m/kV over 150 kV, for wires in Columns IX and X; and
(f) 18 m for wires at rest in Columns XI and XII.
These distances apply with the wire at the swing angle as calculated in Clause 5.2.7. Where the horizontal distances in Items (a) to (f) are exceeded, minimum vertical clearances are determined in relation to the ground over which the line passes.

**On farmlands not likely to be travelled by high farm vehicles, these clearances may be reduced by 0.76 m. Examples include steep slopes, hillsides, and rocky ledges. This does not apply to swamps or other areas that can be crossed by vehicles in winter.

††These areas are generally adjacent to fences and accessible to small vehicles, but are not likely to be travelled by high road vehicles or high farm machinery.

‡‡Seasonal conditions can warrant additional clearances (see Clause 5.3.1.1(e)).

§§See Clause 5.3.1.1(c).

(Continued)

Table 2 (Concluded)

Notes:

(1) *Voltages are rms line-to-ground. Voltages in parentheses are phase-to phase.*

(2) *For elevations exceeding* 1000 m, *see Clause 5.3.1.1(b).*

(3) *For induced electrostatic governing clearances for voltages greater than* 200 kV, *the specified clearances are based on the following horizontal configurations:*

Voltage, kV	*Phase-to-phase spacing, m*	*Number of conductors in bundle*	*Conductor diameter, mm/name*
220 (360)	8.5	2	28.1/*Drake*
318 (500)	10.7	4	25.4/*Mica*
442 (735)	12.8	4	35.1/*Bersimis*

Table 3
Minimum vertical design clearances above waterways*, ac and dc†
(See Clause 5.3.3.2.)

Crossing class	Type of waterways crossed: A = water areas D = water depth W = water width H = reference vessel height‡	Minimum clearance above OHWM, m Guys; messengers; communication, span, and lightning protection wires; communication cables	Open supply conductors and service conductors, ac and dc, kV 0–22	Δ > 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 150	> 150
0	Minor waterways Minor waterway crossings do not require approvals from Transport Canada if they meet the definition of *Minor Works and Minor Navigable Waters (Navigable Waters Protection Act) Order.*	4.42	4.75	5.2	5.5	6.1	6.1 + 0.01 m/kV over 150 kV
1	Shallow or fast-moving waterways capable of being used by canoes and paddle boats in isolated areas where motor boats are not expected. Creeks and streams: W = 3–50 m and D < 1 m Ponds: A < 8 ha and D < 1 m H = 4.0 m	5.0	6.0	6.3	6.7	7.3	7.3 + 0.01 m/kV over 150 kV
2	Shallow or fast-moving waterways capable of being used by motorboats with antennas and unable to support masted vessels Creeks and streams: W = 3–50 m and D < 1 m Ponds: A < 8 ha and D < 1 m H = 6.0 m	7.0	8.0	8.3	8.7	9.3	9.3 + 0.01 m/kV over 150 kV
3	Small lakes and rivers used by masted vessels Rivers: W = 3–50 m and D > 1 m Ponds and lakes: A < 8 ha and D > 1 m H = 8.0 m	9.0	10.0	10.3	10.7	11.3	11.3 + 0.01 m/kV over 150 kV
4	Small resort lakes, medium-sized rivers and reservoirs, rivers connecting lakes, and crossings adjacent to bridges and roads Rivers: W = 50–500 m Lakes/reservoirs: 8 ha < A < 80 ha H = 10.0 m	11.0	12.0	12.3	12.7	13.3	13.3 + 0.01 m/kV over 150 kV

(Continued)

Table 3 (Concluded)

Crossing class	Type of waterways crossed: A = water areas D = water depth W = water width H = reference vessel height‡	Minimum clearance above OHWM, m					
		Guys; messengers; communication, span, and lightning protection wires; communication cables	Open supply conductors and service conductors, ac and dc, kV				
			0–22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 150	> 150
5	Large lakes, reservoirs, and main rivers in resort areas Rivers: W > 500 m Lakes/reservoirs 80 ha < A < 800 ha H = 12.0 m	13.0	14.0	14.3	14.7	15.3	15.3 + 0.01 m/kV over 150 kV
6	Main lakes on main navigation routes and marinas A > 800 ha H = 14.0 m	15.0	16.0	16.3	16.7	17.3	17.3 + 0.01 m/kV over 150 kV
7	Federally maintained commercial channels, rivers, harbours, or heritage canals	§	§	§	§	§	§

The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

†*Clearances are applicable to both ac and dc circuits. For dc circuits, the clearance requirements shall be the same as those for ac circuits having the same crest voltage-to-ground.*

‡*Reference vessel height refers to the overall height of the vessel, including the heights of antennas or other attachments.*

§*Clearances shall be specified by the Transport Canada office responsible for the coastal regions, Great Lakes system, Red River–Lake Winnipeg system, Mackenzie River, and interior lakes of British Columbia. Where tide water has an effect on a body of water being crossed, the vertical design clearance shall be increased by an amount that takes into account peak tide.*

Notes:

(1) *Voltages are rms line-to-ground.*

(2) *The formula used to calculate minimum clearances is as follows:*

Minimum vertical clearance = reference vessel height + 1.0 m buffer + safe electrical clearance

where

1.0 m *buffer* = *allowance for variation in boat height above water (due to different loading conditions) and for wave action*

safe electrical clearance = *safety margin + air gap flashover distance based on switching surge*

= 0.78 m + (0.01 m/kV × *max.* kV *in each column)*

(3) *Vertical design clearance is based on the clearance needed for the vessel height that a waterway can support. If a waterway cannot support the referenced vessel height, the vertical clearance requirement may be reduced in accordance with the appropriate requirement.*

Table 4
Minimum vertical design clearances above ground or rails, dc

(See Clauses 5.3.1.1, 5.7.4.1, and A.5.3.1 and Tables 9 and 11.)

	Minimum vertical clearance above ground or rail, m								
	Open supply-line conductors, dc, kV								
	≥ 0.75 ≤ 100*	> 100 ≤ 150	> 150 ≤ 200	> 200 ≤ 250	> 250 ≤ 300	> 300 ≤ 350	> 350 ≤ 400	> 400 ≤ 450	> 450
Location of conductors	Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX
Over land likely to be travelled by road vehicles (including highways, streets, lanes, alleys, and driveways other than to residences or residence garages)†	5.8	6.0	6.3	6.5	6.7	6.9	7.2	7.4	‡
Over the right-of-way of underground pipelines	5.8	6.0	6.3	6.5	6.7	6.9	7.2	7.4	‡
Alongside land likely to be travelled by road vehicles or within the limits (with no overhang) of streets and highways	5.8	6.0	6.3	6.5	6.7	6.9	7.2	7.4	‡
Over or alongside farmland likely to be travelled by vehicles	5.8	6.0	6.3	6.5	6.7	6.9	7.2	7.4	‡
Over driveways to residences or residence garages	5.6	5.9	6.1	6.3	6.6	6.8	7.0	7.2	‡
Alongside roads and highways in areas unlikely to be travelled by road vehicles (with no overhang) and within 1.5 m of the limit of the road right-of-way§	5.5	5.7	6.0	6.2	6.4	6.6	6.9	7.1	‡
Over walkways or ground normally accessible only to pedestrians, snowmobiles, and personal-use all-terrain vehicles**	4.6	4.8	5.0	5.3	5.5	5.7	6.0	6.2	‡
Above top of rail at railway crossing††	8.8	9.1	9.3	9.5	9.8	10.0	10.2	10.4	‡

**For dc voltages below* 0.75 kV, *use Columns II and III of Table 2.*
†*See Clause 5.3.1.1(d).*
‡*Add* 0.005 m/kV *for each kV over* 450 kV *to clearances in Column VIII.*
§*These areas are generally adjacent to fences and accessible to small vehicles but are not likely to be travelled by high road vehicles or high farm machinery.*
***Seasonal conditions can warrant additional clearances.*
††*See Clause 5.3.1.1(c).*
Note: *Voltages are line-to-ground.*

Table 5
Minimum separations (heights) of supply equipment from ground

(See Clauses 5.3.2.1 and A.5.3.2 and Table 11.)

Type of equipment	Location of equipment	Minimum separation from ground, m			
		0–750 V	> 750 V ≤ 22 kV	> 22 kV ≤ 50 kV	> 50 kV ≤ 90 kV
Live or exposed current-carrying parts of supply equipment (e.g., cable terminals, arresters, line switches) and ungrounded cases of supply equipment (e.g., transformers, regulators, capacitors)	Areas accessible to pedestrians only	3.0	3.4	3.7	4.0
	Areas likely to be travelled by vehicles	4.4	4.7	5.2	5.5
Effectively grounded cases of supply equipment (e.g., transformers, regulators, capacitors)	Areas accessible to pedestrians only	3.0	3.0	3.0	3.0
	Areas likely to be travelled by vehicles	4.4	4.4	4.4	4.4

Note: *Voltages are rms line-to-ground.*

Table 6
Minimum horizontal design clearances between wires and railway tracks

(See Clauses 5.4.2 and 5.4.3.)

Wire closest to tracks		Minimum clearance, m Main tracks	Siding
Guys; messengers; communication, span, and lightning protection wires; communication cables		2.5	1.9
Open supply-line conductors and service conductors of 0–750 V and effectively grounded continuous metallic sheathed cables of all voltages		2.5	1.9
AC	Open supply-line conductors and cables other than those having an effectively grounded continuous metallic sheath		
	> 0.75 ≤ 22 kV	2.7	2.1
	> 22 ≤ 50 kV	3.2	2.6
	> 50 ≤ 90 kV	3.5	2.9
	> 90 ≤ 120 kV	3.8	3.2
	> 120 ≤ 150 kV	4.1	3.5
	Supply conductors > 150 kV	4.1 + 0.01 m/kV over 150 kV	3.5 + 0.01 m/kV over 150 kV
DC	Open supply conductors		
	0–750 V	2.5	1.9
	> 0.75 ≤ 100 kV	2.8	2.2
	> 100 ≤ 150 kV	3.0	2.5
	> 150 ≤ 200 kV	3.3	2.7
	> 200 ≤ 250 kV	3.5	2.9
	> 250 ≤ 300 kV	3.7	3.1
	> 300 ≤ 350 kV	4.0	3.4
	> 350 ≤ 400 kV	4.2	3.6
	> 400 ≤ 450 kV	4.4	3.8
	> 450 kV	4.4 + 0.005 m/kV over 450 kV	3.8 + 0.005 m/kV over 450 kV

Note: *Voltages are line-to-ground.*

Table 7
Minimum horizontal separations from supporting structures to railway tracks

(See Clauses 5.5.2 and 5.5.3.)

Tracks	Minimum horizontal separation, m
Main tracks (straight, level runs)	2.5
Sidings (straight, level runs)	1.9

Table 8
Minimum design clearances of supply conductors attached to buildings
(See Clause 5.7.2.)

Conductor attached to building*		Minimum clearance, m		
		Horizontal to surface	Vertical to normally inaccessible surface	Vertical to readily accessible surface
0–750 V	Insulated or grounded	1.0†	1.0	2.5
	Enclosed in effectively grounded metallic sheath	0	0	0
	Not insulated, grounded, nor enclosed in effectively grounded metallic sheath	1.0†	1.0	2.5
> 0.75 kV ≤ 5 kV	Enclosed in effectively grounded metallic sheath	0	0	0
	Not enclosed in effectively grounded metallic sheath	2.0‡	1.2	2.7
> 5 kV ≤ 22 kV	Enclosed in effectively grounded metallic sheath	0	0	0
	Not enclosed in effectively grounded metallic sheath	2.0§	1.5**	3.0**
> 22 kV	—	2.0 + 0.01 m/kV over 22 kV	3.6 + 0.01 m/kV over 22 kV**††	3.6 + 0.01 m/kV over 22 kV**††

**Clearances are applicable to non-metallic buildings or buildings whose metallic parts are effectively grounded. For other buildings, an assessment might be needed to determine additional clearances for electrostatic induction.*

†For inaccessible surfaces, this value may be reduced to 0.08 m. *At the service attachment point, this value may be further reduced to* 0.02 m.

‡This value may be reduced to 1.2 m *where the building does not have fire escapes, balconies, and windows that can be opened adjacent to the conductor.*

§This value may be reduced to 1.5 m *where the building does not have fire escapes, balconies, and windows that can be opened adjacent to the conductor.*

***Conductors of these voltage classes should not be carried over buildings where other suitable construction can be used.*

††Where it is necessary to carry conductors of these voltage classes over buildings, it should be determined whether additional measures, including increased clearances, are needed to ensure that the crossed-over buildings can be used safely and appropriately.

Note: *Voltages are rms line-to-ground.*

Table 9
Minimum design clearances from wires and conductors not attached to buildings, signs, and similar plant

(See Clauses 5.7.3.1 to 5.7.3.3.)

		Minimum clearance, m			
		To buildings*†		To signs, billboards, lamp and traffic sign standards, and similar plant	
Wire or conductor		Horizontal to surface‡	Vertical to surface	Horizontal to object‡	Vertical to object
Guys, communication cables, and drop wires		0	0.08	0	0.08
Supply conductors					
0–750 V	Insulated or grounded	1.0	2.5§	0.3	0.5
	Enclosed in effectively grounded metallic sheath	0	0	0	0.08
	Not insulated, grounded, or enclosed in effectively grounded metallic sheath	1.0	2.5§	1.0	0.5
> 0.75 kV ≤ 22 kV	Enclosed in effectively grounded metallic sheath	0	0	0	0.08
	Not enclosed in effectively grounded metallic sheath	2.0‡‡	3.0**	2.0	2.5
> 22 kV**††		2.0 + 0.01 m/kV over 22 kV	3.6 + 0.01 m/kV over 22 kV	2.0 + 0.01 m/kV over 22 kV	3.6 + 0.01 m/kV over 22 kV

**Clearances over or adjacent to portions of a building normally traversed by persons or vehicles are specified in Tables 2 and 4.*

†Clearances are applicable to non-metallic buildings or buildings whose metallic parts are effectively grounded. For other buildings, an assessment might be needed to determine additional clearances for electrostatic induction (see Clause 5.7.3.3).

‡Conductor swing shall be added to these values in accordance with Clause 5.7.3.1.

§This clearance may be reduced to 1 m for portions of the building considered normally inaccessible.

***Conductors of these voltage classes should not be carried over buildings where other suitable construction can be used.*

††Where it is necessary to carry conductors of these voltage classes over buildings, it should be determined whether additional measures, including increased clearances, are needed to ensure that the crossed-over buildings can be used safely and effectively.

‡‡This value may be reduced to 1.5 m where the building does not have fire escapes, balconies, and windows that can be opened adjacent to the conductor.

Note: *Voltages are rms line-to-ground.*

Table 10
Minimum design clearances from supply conductors to bridges
(See Clause 5.7.4.2.)

Supply conductor	Minimum design clearance from supply conductor to bridge, m											
	Readily accessible portions*						Inaccessible portions					
	Horizontal		Vertical				Horizontal		Vertical			
	Conductor attached to bridge	Conductor not attached	Conductor attached to bridge: Over bridge	Conductor attached to bridge: Under bridge	Conductor not attached: Over bridge	Conductor not attached: Under bridge	Conductor attached to bridge	Conductor not attached	Conductor attached to bridge: Over bridge	Conductor attached to bridge: Under bridge	Conductor not attached: Over bridge	Conductor not attached: Under bridge
0–750 V	1.2†	1.2†	2.5	0.3	2.5	0.3	0.15	0.3	0.9	1.5	2.5	0.3
> 0.75 ≤ 22 kV	1.5	1.5	2.7	0.9	2.7	0.9	0.5	0.6	1.2	0.5	2.7	0.9
> 22 ≤ 50 kV	1.8	1.8	3.0	1.2	3.0	1.2	0.9	0.9	1.5	0.9	3.3	1.2
> 50 kV ac	Clearances required at > 22 and ≤ 50 kV + 0.010 m/kV over 50 kV											
> 50 kV dc	Clearances required at > 22 and ≤ 50 kV + 0.005 m/kV over 50 kV											

**Readily accessible portions include portions of a bridge likely to be used by workers and portions readily accessible to the public. Bridge seats of steel bridges supported by masonry, brick, or concrete abutments that need periodic inspection should be considered readily accessible portions. Concrete, brick, or masonry portions that need to be passed by workers so that they can gain access to other areas shall be considered readily accessible portions.*

†This clearance may be reduced to 1 m where the portion of the bridge involved is readily accessible to workers but not to the public.

Notes:

(1) *Voltages are rms line-to-ground.*

(2) *Grounding conductors or conductors installed in effectively grounded conduit do not require clearance under a bridge.*

Table 11
Minimum separation of equipment and clearances of conductors from swimming pools
(See Clauses 5.7.5 and A.5.7.5 and Figure 1.)

Equipment or conductors	Minimum separation or clearance, m	
	A — Measured in any direction from the water level, edge of pool, or diving platform	B — Measured vertically over land
Supply equipment	4.6	See Clause 5.3.2 and Table 5
Guys, messengers, span wires, communication circuits, secondary cable 0–750 V, and multi-grounded neutral conductors	4.6	See Clause 5.3.1 and Tables 2 and 4
Other supply conductors ≤ 22 kV	6.7	See Clause 5.3.1 and Tables 2 and 4
Supply conductors > 22 kV and ≤ 150 kV	6.7 + 0.01 m/kV above 22 kV	See Clause 5.3.1 and Tables 2 and 4
Supply conductors > 150 kV	*	See Clause 5.3.1 and Tables 2 and 4

**Supply conductors greater than* 150 kV *shall not cross over swimming pools or be closer to the edge of a pool than* 8.0 m + 0.01 m/kV *above* 150 kV.

Notes:

(1) *Voltages are rms line-to-ground.*

(2) *See Figure 1 for an illustration of swimming pool clearance limits.*

Table 12
Minimum horizontal separations from supply equipment to buildings
(See Clauses 5.7.6 and A.5.7.6.)

Voltage	Equipment	Minimum separation from building, m			
		Attached equipment		Unattached equipment	
		Normally inaccessible	Readily accessible	Normally inaccessible	Readily accessible
0–750 V	Effectively grounded equipment	0	0	0.15	1.0
	Exposed live parts*	1.0	†	1.0	1.0
> 0.75 ≤ 22 kV	Effectively grounded equipment	0	†	0.15	1.0
	Exposed live parts*	1.5	†	1.5	2.0

**Exposed live parts include any parts not effectively grounded.*

†*This equipment shall not be attached in any readily accessible location.*

Note: *Voltages are rms line-to-ground.*

Table 13
Minimum design vertical clearances between wires crossing each other and supported by different supporting structures

(See Clauses 5.8.1.1, 5.8.1.2, A.5.8.1, and A.5.8.1.3.)

Type of line wire, cable, or other plant being crossed over	Line wire or cable at upper level, minimum clearance, m																		
	Guys, span wires, aerial grounding conductors, and communication wires and cables	Open supply-line conductors and service wires																	
		ac, kV										dc, kV							
		0–0.75	> 0.75 ≤ 22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 120	> 120 ≤ 150	> 150 ≤ 190	> 190 ≤ 220	> 220 ≤ 320	> 320 ≤ 425	0–100	> 100 ≤ 150	> 150 ≤ 200	> 200 ≤ 250	> 250 ≤ 300	> 300 ≤ 350	> 350 ≤ 400	> 400 ≤ 450
Communication wires and cables	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.4	2.7	3.9	4.6	0.6	0.8	1.1	1.2	1.4	1.7	1.8	2.0
Open supply conductors, ac, kV 0–0.75	—	0.3	0.5	0.8	1.1	1.4	1.7	2.2	2.6	3.7	4.4	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9
> 0.75 ≤ 22	—	—	0.6	0.9	1.2	1.5	1.7	2.3	2.7	3.8	4.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
> 22 ≤ 50	—	—	—	1.1	1.4	1.7	2.0	2.4	2.8	4.0	4.6	1.1	1.2	1.3	1.4	1.6	1.7	1.8	2.1
> 50 ≤ 90	—	—	—	—	1.5	1.8	2.1	2.7	3.0	4.2	4.9	1.3	1.4	1.5	1.7	1.8	1.9	2.1	2.2
> 90 ≤ 120	—	—	—	—	—	2.0	2.3	2.8	3.2	4.3	5.0	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4
> 120 ≤ 150	—	—	—	—	—	—	2.4	3.0	3.4	4.5	5.2	1.9	2.1	2.2	2.3	2.4	2.5	2.7	2.8
> 150 ≤ 190	—	—	—	—	—	—	—	3.1	3.6	4.7	5.4	2.4	2.6	2.7	2.8	2.9	3.0	3.2	3.4
> 190 ≤ 220	—	—	—	—	—	—	—	—	3.7	4.9	5.6	2.9	3.0	3.1	3.3	3.4	3.5	3.7	3.8
> 220 ≤ 320	—	—	—	—	—	—	—	—	—	5.4	6.1	—	4.1	4.3	4.4	4.5	4.6	4.7	4.9
> 320 ≤ 425	—	—	—	—	—	—	—	—	—	—	6.7	—	—	4.9	5.1	5.2	5.3	5.5	5.6

(Continued)

Table 13 (Concluded)

Type of line wire, cable, or other plant being crossed over	Line wire or cable at upper level, minimum clearance, m																		
	Guys, span wires, aerial grounding conductors, and communication wires and cables	Open supply-line conductors and service wires																	
		ac, kV										dc, kV							
		0–0.75	> 0.75 ≤ 22	> 22 ≤ 50	> 50 ≤ 90	> 90 ≤ 120	> 120 ≤ 150	> 150 ≤ 190	> 190 ≤ 220	> 220 ≤ 320	> 320 ≤ 425	0–100	> 100 ≤ 150	> 150 ≤ 200	> 200 ≤ 250	> 250 ≤ 300	> 300 ≤ 350	> 350 ≤ 400	> 400 ≤ 450
Trolley contact conductors*, dc, kV 0–0.75	0.6	0.6	0.9	1.2	1.5	1.8	2.1	2.7	3.0	4.2	4.9	0.9	1.2	1.4	1.5	1.8	2.0	2.1	2.4
> 0.75–100	—	—	—	—	1.3	1.5	2.0	2.4	2.9	4.0	4.7	0.7	0.8	1.1	1.2	1.4	1.7	1.8	2.0
> 100 ≤ 150	—	—	—	—	1.4	1.7	2.1	2.6	3.0	4.1	4.9	0.8	0.9	1.2	1.4	1.5	1.8	2.0	2.1
> 150 ≤ 200	—	—	—	—	1.5	1.8	2.1	2.7	3.1	4.4	4.9	1.1	1.2	1.3	1.4	1.7	1.9	2.0	2.3
> 200 ≤ 250	—	—	—	—	1.7	1.9	2.3	2.8	3.3	4.4	5.1	1.2	1.4	1.4	1.6	1.8	2.0	2.2	2.4
> 250 ≤ 300	—	—	—	—	1.8	2.1	2.4	3.0	3.5	4.5	5.3	1.4	1.5	1.7	1.8	2.0	2.1	2.4	2.6
> 300 ≤ 350	—	—	—	—	1.9	2.1	2.6	3.1	3.5	4.6	5.3	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.7
> 350 ≤ 400	—	—	—	—	2.1	2.3	2.7	3.2	3.7	4.8	5.5	1.8	2.0	2.0	2.2	2.4	2.4	2.6	2.8
> 400 ≤ 450	—	—	—	—	2.2	2.4	2.8	3.4	3.8	4.9	5.6	2.0	2.1	2.3	2.4	2.5	2.7	2.8	3.0
Guys, span wires, and aerial grounding wires	0.2	0.2	0.5	0.8	1.2	1.5	1.8	2.4	2.7	3.9	4.6	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9

**Where the trolley pole is not prevented from de-wiring, the clearance shall be increased so as to maintain the minimum specified clearance between the trolley pole in the de-wired position and the crossing conductor.*

Note: *Voltages are rms line-to-ground.*

Table 14
Minimum vertical clearances for crossings over aerial tramways
(See Clause 5.8.1.1.)

Type of plant being crossed over	Line wire or cable at upper level, minimum clearance, m											
	Communication conductors and cables, span and grounding wires carried aerially	ac									dc	
		0–750 V	> 0.75 kV ≤ 22 kV	> 22 kV ≤ 50 kV	> 50 kV ≤ 90 kV	> 90 kV ≤ 120 kV	> 120 kV ≤ 150 kV	> 150 kV ≤ 220 kV	> 220 kV ≤ 320 kV	> 320 kV ≤ 425 kV	320–425 kV	0–100 kV
Aerial tramways												
Gondolas and similar apparatus providing a roof over passengers	0.15	0.15	0.5	0.8	1.2	1.5	1.8	2.4	2.7	3.9	4.6	0.5
Chairlifts, T-bars, and similar apparatus or towers of any type of aerial tramway	1.7	1.7	2.0	2.3	2.7	3.0	3.4	3.9	4.3	5.4	6.0	2.0

Note: *Voltages are rms line-to-ground.*

Table 15
Clearance increments to be added to horizontal displacement

(See Clauses 5.8.2 and A.5.8.2.)

Sum of voltages of conductors*	Clearance increment, mm
0–750 V	300
> 750 V ac	300 + 10 mm/kV over 750 V
> 750 V dc	300 + 6 mm/kV over 750 V

**Communication conductors are assumed to operate at less than 130 V dc at 0.25 A or less per pair (1500 pairs or fewer).*

Note: *Voltages are rms line-to-ground.*

Table 16
Minimum design clearances between conductors of one line and supporting structures of another line

(See Clause 5.8.3.1.)

Voltage of line conductor*, kV	Minimum clearance between conductor and supporting structure, mm
0–5	1000 wherever practicable, but in no case less than (a) 150 for spans 0–6 m; (b) 230 for spans > 6 and ≤ 15 m; and (c) 300 for spans > 15 m
> 5 and ≤ 22	1000 wherever practicable, but in no case less than 500
> 22 and ≤ 50	1000
> 50	1000 + 10 mm/kV over 50 kV

**Communication conductors are assumed to operate at less than 130 V dc at 0.25 A or less per pair (1500 pairs or fewer).*

Note: *Voltages are rms line-to-ground.*

Table 17
Minimum horizontal separations of supply-line conductors attached to the same supporting structure

(See Clauses 5.9.1.1, 5.9.1.2, and 5.9.1.3.)

<table>
<tr><th>Line conductor</th><th colspan="2">Minimum separation of conductors for spans ≤ 50 m, mm</th><th>Minimum separation of conductors for spans > 50 m and ≤ 450 m*, mm</th></tr>
<tr><td>0–5 kV ac†</td><td>Span length
0–6 m
> 6 m and ≤ 50 m</td><td>Separation
225
300</td><td rowspan="2">300 + the following three increments:
(a) 3 × the distance (in m) by which the span length exceeds 50 m;
(b) 83 × the final unloaded sag (in m) at 15 °C conductor temperature for conductor(s) having the greatest sag; and
(c) 10 mm/kV over 5 kV</td></tr>
<tr><td>> 5 kV ac†</td><td colspan="2">300 + 10 mm/kV over 1 kV</td></tr>
<tr><td>0–750 V dc, same polarity, different circuits‡</td><td colspan="2">150</td><td>150 + increments (a) and (b) above</td></tr>
<tr><td>0–750 V dc, opposite polarity</td><td colspan="2">300</td><td>300 + increments (a) and (b) above</td></tr>
<tr><td>> 0.75 kV and ≤ 22 kV dc, same polarity, different circuits‡</td><td>Span length
0–6 m
> 6 m and ≤ 50 m</td><td>Separation
225
300</td><td>300 + increments (a) and (b) above</td></tr>
<tr><td>> 0.75 kV and ≤ 22 kV dc, opposite polarity</td><td colspan="2">375</td><td>375 + increments (a) and (b) above</td></tr>
<tr><td>> 22 kV dc</td><td colspan="2">375 + 5 mm/kV over 22 kV</td><td>375 + 5 mm/kV over 22 kV plus increments (a) and (b) above</td></tr>
</table>

*For spans longer than 450 m, the separation shall be based on best engineering practices, but shall be not less than the separations specified for spans of 450 m.

†Phase-to-phase voltages for the same circuit or the sum of phase-to-ground voltages for different circuits.

‡There is no minimum separation for conductors of the same polarity in the same circuit.

Table 18
Minimum vertical separations between supply-line conductors attached to the same supporting structure, ac
(See Clause 5.9.2.1.)

Conductors at lower level	Minimum vertical separation, m				
	Conductors at higher level				
	0–750 V	> 0.75 kV ≤ 5 kV	> 5 kV ≤ 22 kV	> 22 kV ≤ 50 kV	> 50 kV ≤ 90 kV
0–750 V*	0.1	0.4	0.4	1.0	1.5
> 0.75 kV ≤ 5 kV	—	0.4	0.4	1.0	1.5
> 5 kV ≤ 22 kV	—	—	0.4†	1.0	1.5
> 22 kV ≤ 50 kV	—	—	—	1.0†	1.5
> 50 kV ≤ 90 kV	—	—	—	—	1.5†

This category also includes dc.

†*This value does not apply to conductors on adjacent supports of the same circuit or circuits.*

Note: *Voltages are rms line-to-ground.*

Table 19
Vertical spacings between supply-line conductors of 0 to 750 V on vertical brackets
(See Clause 5.9.2.2.)

Maximum span length, m	Minimum average spacing at brackets, mm
20	100
45	150
60	200
75	250

Table 20
Minimum in-span vertical clearances between supply conductors of the same circuit that are attached to the same supporting structure

(See Clause 5.9.2.3.)

Maximum circuit line-to-ground voltage, kV	Minimum clearance, mm	
	Between multi-grounded neutral and circuit conductor	Between circuit conductors
0.750	100	100
5	150	150
10	150	250
15	250	300
22	350	450
50	750	900
90	1000	1250

Table 21
Minimum in-span vertical clearances between supply conductors of different circuits that are attached to the same supporting structure

(See Clause 5.9.2.4.)

Maximum lower conductor line-to-ground voltage, kV	Minimum in-span vertical clearance, mm						
	Maximum upper conductor line-to-ground voltage, kV						
	5	10	17	22	30	50	90
0.750	150	150	250	350	450	750	1000
5	150	200	250	350	450	750	1000
10	—	250	300	400	450	800	1050
17	—	—	300	400	500	800	1050
22	—	—	—	450	500	800	1050
30	—	—	—	—	550	850	1100
50	—	—	—	—	—	900	1150
90	—	—	—	—	—	—	1250

Table 22
Minimum separations or clearances in any direction from supply conductors to other supply plant attached to the same supporting structure

(See Clauses 5.9.5 and A.5.9.5.)

Between	Separation or clearance, mm						
	Voltage of conductor(s), ac*				Voltage of conductor(s), dc		
	0–750 V	> 0.75 kV ≤ 5 kV	> 5 kV ≤ 22 kV	> 22 kV ≤ 50 kV†	0–750 V	> 0.75 kV ≤ 22 kV	> 22 kV ≤ 50 kV†
Supply lateral, vertical, or line conductors *and* supply lateral or vertical conductors of the same or different circuits but not connected together	75	100	300	‡	75	120	§
Supply lateral, vertical, or line conductors *and* surface of structure, crossarms, and other non-energized supply plant, including grounding conductors	75**	100	150	‡	75‡	120	§
Supply lateral, vertical, or line conductors *and* span or guy wire, except where conductors are supported by the span wire	100††	170††‡‡	380	‡††	75††	200††‡‡	§
Supply-line conductor *and* lightning protection wire parallel to the line	§§	§§	§§	§§	§§	§§	§§

**Clearances from connecting wires to switches or arresters may be less than that from line wires to switches or arresters.*
†*For voltages exceeding* 50 kV, *clearances shall be based on best engineering practices, but shall be not less than the separations specified for* 50 kV.
‡*Add* 10 mm/kV *over* 22 kV.
§*Add* 5 mm/kV *over* 22 kV.
***This clearance may be reduced to* 0 mm *for conductors and cables* 0–750 V, *provided that the conductors are attached to the surface of the structure and grounded or covered by material of adequate insulating and mechanical properties.*
††*Where this clearance cannot be achieved, adequate insulation shall be applied to the supply conductor.*
‡‡*This clearance shall be increased to* 300 mm *for voltages* 0.75–8 kV *for a span wire or span guy wire running parallel to the supply conductor.*
§§*The clearance shall be not less than the separations specified in Clause 5.9.1.*
Note: *Voltages are rms line-to-ground.*

Table 23
Minimum vertical separations at a joint-use structure

(See Clauses 5.10.1.1, 5.10.1.6, 5.10.1.7, 5.10.6.2, and A.5.10.1 and Figures A.6 and A.7.)

Between	Minimum vertical separation, m		
	Voltage of supply conductors		
	0–750 V	> 0.75 kV ≤ 22 kV	> 22 kV ≤ 50 kV*
Live or current-carrying supply plant (including neutrals) *and* communication line plant	1.0†	1.2‡	1.5‡
Non-energized supply plant (excluding luminaire span wire and brackets) *and* communication line plant			
Option A§			
Ungrounded	1.0†	1.0	1.5
Effectively grounded**	0.75†	0.75†	1.0
Option B§			
Ungrounded	0.75	1.0	1.5
Effectively grounded**	0.10	0.30	0.30
Trolley span wires or brackets *and* communication line plant	0.30	N/A	N/A
Luminaire span wires or brackets *and* communication line plant			
Ungrounded	1.0	1.0	N/A
Effectively grounded	0.10	0.10	N/A
Point of attachment of combined communication drop and supply service conductor *and* communication line plant	1.0†	N/A	N/A
Housing containing communication power supply or communication compressor dehydrator (effectively grounded) *and* communication cable	0	N/A	N/A

**For voltages greater than* 50 kV, *add* 0.010 m/kV *over* 50 kV.
†*On lateral communication drop wire plant, this separation may be reduced to* 0.6 m *from the communication plant.*
‡*See Clause 5.2.6 for requirements for neutral conductors.*
§*Option A or Option B shall be selected in accordance with Clauses 5.10.1.6 and 5.10.1.7.*
***Where it is unclear whether the non-energized plant is effectively grounded, the ungrounded separations shall apply.*
Note: *Voltages are rms line-to-ground.*

Table 24
Minimum in-span vertical clearances between supply and communication conductors

(See Clauses 5.10.3.2 and A.5.10.3.)

Voltage of supply conductor	Minimum clearance of supply conductor above line of sight of points of support of highest communication wire or cable, mm
0–750 V with thermoplastic weatherproof covering	2*
0–750 V with other covering or bare	75*†
> 0.75 kV and ≤ 15 kV	300
> 15 kV and ≤ 22 kV	380
> 22 kV and ≤ 250 kV	380 + 10 mm/kV over 22 kV

**For effectively grounded neutral, see Clause 5.10.3.3.*

†*While the use of the design limit of* 75 mm *can yield a minimum actual clearance of approximately* 300 mm *under the worst expected conditions, most situations will result in clearances in excess of* 600 mm.

Note: *Voltages are rms line-to-ground.*

Table 25
Minimum clearances from guys to plant of another system

(See Clauses 5.11.2.1 and A.5.11.2 and Figure A.8.)

Type of plant near which the guy passes	Minimum clearance, m
Communication line plant	0.6
Trolley contact conductors, dc	
0–750 V	1.2
> 0.75 kV and ≤ 22 kV	1.8
> 22 kV	1.8 + 0.01 m/kV over 22 kV
Current-carrying supply plant, ac	
0–750 V	0.6
> 0.75 kV and ≤ 22 kV	1.2
> 22 kV	1.2 + 0.01 m/kV over 22 kV
Supply guy wires and span wires	0.6

Note: *Voltages are rms line-to-ground.*

Table 26
Minimum clearance or separation between guys and other plant attached to the joint-use structure

(See Clauses 5.11.2.2 and A.5.11.2 and Figure A.8.)

	Minimum clearance or separation from guy, mm	
Type of plant over or near which the guy passes	Guy not parallel to plant	Guy parallel to plant
Communication line plant	150*	75
Current-carrying supply plant		
0–750 V	150	150*
> 0.75 kV and ≤ 5 kV	150	230
> 5 kV and ≤ 15 kV	230	300
> 15 kV and ≤ 22 kV	300	380
> 22 kV	300 + 10 mm/kV over 22 kV	380 + 10 mm/kV over 22 kV

*This clearance may be reduced to 75 mm where adequate insulation is provided.

Note: *Voltages are rms line-to-ground.*

Table 27
Minimum grades of construction for crossings

(See Clauses 6.3.1, 6.3.2.1, 7.8.1.1, 7.8.2, 7.8.3, 7.9.1, A.7.8.2, and A.8.1.)

	Minimum grade of construction where the conductors, messengers, or cables are at the upper level		
Item at lower level	Communication	0–750 V	> 750 V
Railway control facilities and tracks	1	1	1
Limited- or controlled-access highways	1	1	1
Roads and highways — General	3	3	3
Pipelines	3	3	3
Navigable waterways requiring permits	1	1	1
Aerial tramways	1	1	1
Other private or public property	3	3	3
Communications			
Cable	3	3	1*
Open wire — General	3	3	1*
Drop wire	3	3	3
Supply			
0–750 V	2†	3	2‡
> 750 V	1†	2	2

**The grade of construction may be Grade 2 where one of the following conditions exists:*
(a) the supply and communication lines have coordinated electrical protection (see Clause 4.4);
(b) where coordinated electrical protection is not practical, the supply conductors have a breaking strength of 12.4 kN or greater; or
(c) the supply conductors are enclosed in effectively grounded continuous metallic sheathed cable.
†The communication line may be Grade 3 where the supply conductors are in effectively grounded continuous metallic sheathed cable.
‡Grade 3 construction may be used where the supply conductors at the upper level are in effectively grounded continuous metallic sheathed cable.

Table 28
Minimum grades of construction for proximities

(See Clauses 6.3.1, 6.3.3, 7.8.1.1, 7.8.2, 7.8.3, 7.9.1, A.7.8.2, and A.8.1.)

	Minimum grade of construction		
In proximity to	Communication conductors, messengers, or cables	Conductors 0–750 V or effectively grounded continuous metallic sheathed supply cables of all voltages	Conductors > 750 V
Railway control facilities and tracks	1	1	1
Limited- or controlled-access highways	1	1	1
Roads and highways — General	3	3	3
Pipelines and waterways that do not require permits	3	3	3
Navigable waterways requiring permits	1	1	1
Aerial tramways	1	1	1
Other private or public property	3	3	3
Communications			
Cable	3	2	1*
Open wire — General	3	2	1*
Drop wire	3	3	3
Supply			
0–750 V	2	3	2†
> 750 V	1	2	2

**The line may be Grade 2 if the supply and communications lines have coordinated electrical protection (see Clause 4.4).*
†Grade 3 construction may be used where the supply conductors at the upper level, or the supply conductors creating the proximity, are in effectively grounded continuous metallic sheathed cable.

Table 29
Minimum grades of construction for joint use

(See Clauses 6.3.1, 6.3.4, 7.8.1.1, 7.8.2, 7.8.3, 7.9.1, A.7.8.2, and A.8.1.)

	Minimum grade of construction	
Conductor at lower levels	Conductors 0–750 V or effectively grounded continuous metallic sheathed supply cables of all voltages	Conductors > 750 V
Communications		
Cable	2	1*
Open wire in general	2	1*
Drop wire	3	3
Supply		
All voltages	3	3

**The grade of construction may be Grade 2 where one of the following conditions exists:*
(a) the supply and communications lines have coordinated electrical protection (see Clause 4.4);
(b) where coordinated electrical protection is not practical, the supply conductors have a breaking strength of 12.4 kN or greater; or
(c) the supply conductors are enclosed in effectively grounded continuous metallic sheathed cable.

Table 30
Deterministic weather loads*†

(See Clauses 7.2, 7.3.1, 7.3.5, 7.5.1, 7.6.2.1, and A.7.3.)

	Loading area‡			
			Medium	
Loading conditions	Severe	Heavy	A	B
Radial thickness of ice, mm	19	12.5	6.5	12.5
Horizontal wind loading, N/m^2	400	400	400	300
Temperature	–20 °C	–20 °C	–20 °C	–20 °C

**When large conductors are used in locations where high winds are prevalent, the loading on bare conductors should be assessed, as high winds can produce a transverse loading in excess of the wind and ice combinations.*
†On small conductors, the ice effect is more significant than on large conductors, as it constitutes a greater percentage of the total mass.
‡See Clause 7.2 and Annex C.

Table 31
Minimum load factors for non-linear analysis of structures

(See Clauses 7.4.2, 7.5.2, 7.6.4, 7.7.2, 7.8.1.2, 7.8.2.4, 8.1.3, 8.3.10.1, 8.3.12.2, and A.7.4.2.)

Type of load	Construction grade	Minimum load factor		
		Material		
		COV ≤ 10%	10% < COV < 20%	COV ≥ 20%
Vertical	1	1.30	1.60	2.00
	2	1.15	1.30	1.50
	3	1.00	1.10	1.20
Transverse	1	1.20	1.50	1.90
	2	1.10	1.20	1.30
	3	1.00	1.10	1.10
Longitudinal with terminations or tension changes	1	1.20	1.50	1.90
	2	1.10	1.20	1.30
	3	1.00	1.10	1.10
Longitudinal without terminations or tension changes	1	1.10	1.20	1.20
	2	1.00	1.00	1.00
	3	1.00	1.00	1.00

Notes:

(1) *Non-linear analysis, including stability (buckling) check, is the method of analysis of wood structures that should be used. Linear analysis of wood pole structures continues to be utilized in some jurisdictions in accordance with historical utility practice and remains an option for users during a period of transition to non-linear analysis. The minimum load factors for linear analysis of wood pole structures, which were specified in past editions of this Standard, are reproduced in Table E.1.*

(2) *Further information regarding the non-linear design method applied to poles, including sample calculations, can be found in ASCE Manual 111.*

(3) *Default COV values for pole and structure materials are:*
- *(a) steel — ≤ 10%;*
- *(b) concrete — 10% < COV < 20%; and*
- *(c) wood — ≥ 20%.*

(4) *The selection of appropriate minimum load factors for steel, concrete, fibre-reinforced composite, laminated wood, and wood poles is based on the coefficient of variation (COV), for the given pole material as verified by the pole manufacturer. The lowest minimum load factors (i.e., steel pole default values) may be used for concrete, laminated wood, and fibre-reinforced composite structures, provided that the manufacturers can verify through required testing that the COV of the poles in question is less than or equal to 10%. Similarly, the next lowest minimum load factors (i.e., concrete pole default values) may also be used for fibre-reinforced composite and laminated wood structures, provided that the manufacturers can verify through required testing that the COV of the poles in question is greater than 10% but less than 20%. The highest minimum load factors (i.e., wood pole default values) shall be used for fibre-reinforced composite or laminated wood poles in the event that the manufacturer is unable to verify that the COV of the poles in question is less than 20%.*

Table 32
Minimum load factors for guy assemblies at installation
(See Clauses 7.4.2, 7.6.4, 7.7.2, 7.8.1.2, 7.8.2.4, 8.3.10.2, 8.3.12.3, and A.7.4.2.)

Type of load	Minimum load factor		
	Grade 1	Grade 2	Grade 3
Transverse (including angles)	1.6	1.25	1.0
Longitudinal			
With terminations or tension changes	1.6	1.25	1.0
Without terminations or tension changes	1.0	—	—

Table 33
Conductor tensioning — Recommended catenary parameter
(See Clauses 8.7.3 and A.8.7.3.)

Span length, m	Recommended initial maximum catenary*, m
> 400	2000
> 350 and ≤ 400	1900
> 300 and ≤ 350	1800
> 250 and ≤ 300	1700
> 200 and ≤ 250	1600
> 150 and ≤ 200	1500
> 100 and ≤ 150	1400
< 100	1300

**The reduction of the catenary value in relation to the span is based on the principle that lower tensions are safer than higher ones from the point of view of aeolian vibrations. This reduction will not affect the sags significantly, but will reduce loads on angle structures.*

Table 34
Maximum tensions for galvanized steel wire strand lightning protection wires

(See Clause 8.8.2.)

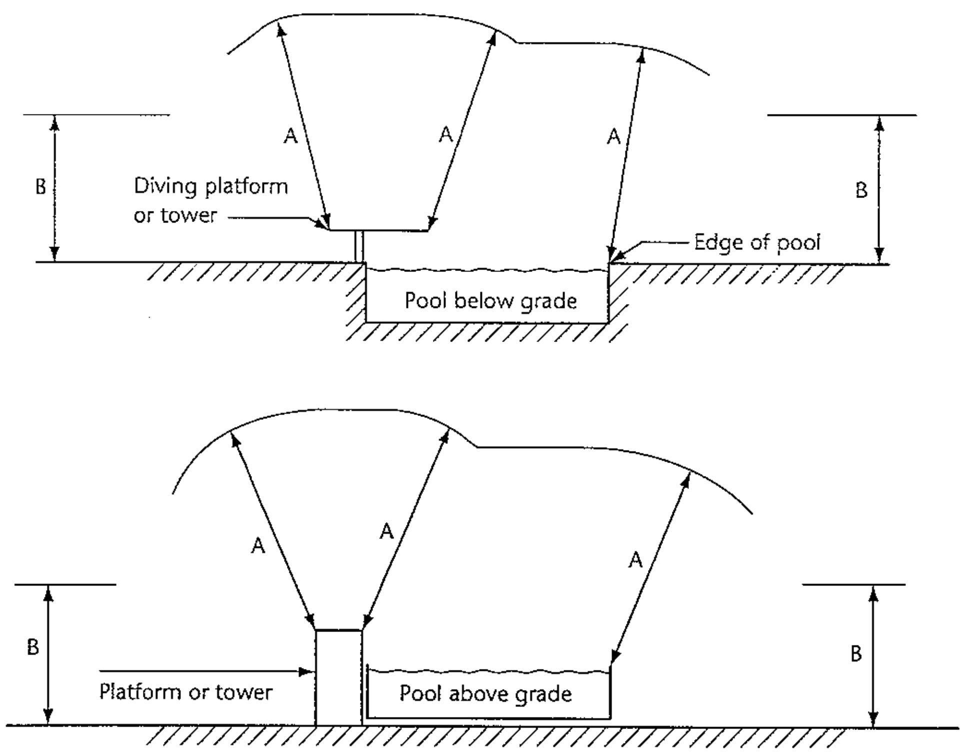
Loading conditions	Maximum tension, % of ultimate tensile strength
Maximum allowable tension under appropriate loading conditions	60
Maximum recommended initial unloaded tension at the mean annual temperature	20
Maximum recommended final unloaded tension at the mean annual temperature	15

Note: *The unloaded tension is intended only as a guide. The unloaded tension may be increased when factors that produce conductor fatigue are at a minimum or when suitable steps are taken to suppress fatigue failure.*

Table 35
Flashover distance for ac conductors for tree pruning

(See Clause 4.1.7.)

Maximum line-to-ground voltage, kV	Flashover-to-ground distance, mm
0.75	8
5	72
10	144
15	216
22	316
50	718
90	970
120	1185
150	1586
190	2129
220	2566
250	3000
318	3640
442	4600



Note: *See Table 11 for the minimum clearance values for A and B.*

Figure 1
Swimming pool clearance limits
(See Clause 5.7.5 and Table 11.)

Annex A (informative) **Commentary**

Notes:
(1) *This Annex is not a mandatory part of this Standard.*
(2) *The clause numbers in this Annex correspond to the clauses in this Standard.*
(3) *The tables and figures in this Annex do not correspond to the tables and figures in this Standard.*

A.1 Scope

A.1.5

The requirements of this Standard are designed to provide a minimum acceptable class of construction for application over a broad area. Requirements more stringent than the specified minimum should be met where

- a utility's own experience indicates that more severe weather conditions are common in specific areas;
- it is necessary to obtain acceptable radio influence voltage (RIV); or
- the security level of a circuit warrants more stringent requirements.

A.3 Definitions and abbreviations

A.3.1 Definitions

The user of this Standard should fully understand the definitions and note that, in accordance with the definitions, specified voltages are voltages-to-ground unless otherwise noted.

A.4 General requirements

A.4.1 General design and maintenance

Owners of lines should be aware of the specific terrain, exposure to climate, traffic, accessibility, and other relevant matters concerning their lines and equipment, and should have the competence to design, build, and maintain the lines accordingly.

The requirements of this Standard are the minimum considered to be adequate for the expected conditions. These minimum requirements are based on reasonable electrical and mechanical criteria and do not include additional amounts for special circumstances. Where conditions are expected to be more severe, the owner is responsible for exercising judgment and for making appropriate adjustments in design to meet the general intent of this Standard or the objectives of good practice.

A.4.1.4 Climbing space

For examples of climbing space involving drop wires, see Figure A.1.

Additional requirements for tall structures should be based on good practice. Individual safety authorities might necessitate more specific measures.

A.4.2 Structures and attachments

During the selection of a site, consideration should be given to the protection of the new structure from damage, as well as to any hazard the new structure might present. The possibility of unauthorized access by means of the structure to adjacent property, or any easily accessible means allowing the public to climb the structure, should be eliminated to the greatest extent practicable.

These considerations also apply to the maintenance of existing structures. Attention is needed to ensure correction of any unsatisfactory conditions arising after the plant has been constructed.

A.4.2.7 Grounding and insulating of guys

A.4.2.7.1 General

Clause 4.2.7.1 is intended to protect the public and workers from contacting an energized guy wire. Where a guy is located above an energized conductor, the guy needs to be insulated or separately grounded so that, if the guy is broken at the ground line, its upper portion will remain insulated or grounded. The separate ground may be provided by connection to a multi-grounded neutral, another grounded guy, or any other effective ground.

Where the guy wire is located below the conductor, the only hazard is contact between a broken conductor and the guy wire. The metal anchor rod may be considered an effective ground where the soil resistance is suitably low. When using a guy as an effective ground where the guy is not continuously under tension, it might be necessary to ensure the electrical conductivity of the mechanical connection between the guy wire and the anchor by means of a jumper or similar device.

A.4.4 Coordinated electrical protection

Every attempt should be made to achieve coordinated electrical protection between power and communication circuits; a stronger grade of construction is not an equivalent (see CSA C22.3 No. 5.1). However, stronger grades of construction may be used where they are the only option.

A.5 Clearances, separations, and spacings

Clause 5 covers clearances, separations, and spacings involving overhead line components and their relationships to each other, to the ground, and to other plant.

The following basic factors were considered in the preparation of Clause 5:

- a protected zone that accounts for such factors as the height of a vehicle, the reach of a pedestrian, and the access area around a building or equipment;
- a clearance (separation or spacing) between grounded or non-energized supply plant and other grounded or non-energized plant, persons, or objects that offers a protected zone and provides for the swing of wires or the swing of conductors and insulators;
- a clearance from an energized supply plant to other energized or non-energized objects or persons that offers a protected zone and provides for the greater of the distance needed to withstand an electrical flashover and the distance needed to prevent an unsafe level of induced current in a vehicle under or adjacent to an extra-high-voltage line; and
- a small buffer added to the items specified above. For example, for road crossings, a rounding of the clearance requirement results in a buffer of about 0.3 m.

The electrical flashover distance used when calculating clearances is based on the voltage under switching surge conditions. To arrive at distances considered safe, adequate values of surge overvoltages were chosen, based on systems being designed at the time of drafting of this Standard. The clearances in the tables, however, apply an increment for voltage to the normal (rms) operating voltage. The values assumed for the switching surge overvoltage factors, the surge voltage, and the resulting air gap distance are given in Tables A.1 and A.2.

The examples for Tables 2 and 4 given in Clause A.5.3.1 show the justification for applying a voltage increment of 0.01 m/kV to the rms voltage by calculating the clearance in two ways: using the test data and using the simplified approximation of 0.01 m/kV.

This increment for voltage of 0.01 m for each kilovolt of normal (rms) operating voltage has been commonly used in both the Canadian Electrical Code and ANSI/IEEE-C2. This is a derived value applied to the normal (rms) operating voltage, but calculated so that it accounts for switching overvoltage conditions.

The following air gap flashover data for ac and dc systems are used in the basic calculations of Clause 5.2:

- AC systems: full-scale wet switching surge tests on ac conductor-to-ground plane configurations have shown that the flashover strength of air gaps is relatively uniform up to a switching surge voltage of approximately 500 kV. Beyond this, the strength of air gaps is reduced (i.e., a given air gap withstands a smaller voltage). Using this data, the following values are derived for use in this Standard:
  - for 500 kV or less, a safe approximation for the air gap withstand is 2.54 mm/kV; and
  - for greater than 500 kV, a safe approximation for the air gap withstand is 3.81 mm/kV.
- DC systems: from full-scale switching surge tests on dc conductor-to-ground configurations, the following values are used for this Standard:
  - for 144 kV or less, the air gap withstand is 2.0 mm/kV; and
  - for greater than 144 kV, the air gap withstand is 2.92 mm/kV.

A.5.2 General application

A.5.2.2 Vertical design clearances at maximum sag

When the maximum sag is determined by ice and wind conditions, it is recognized that the plane of the conductor is in a position of swing; however, for simplicity, it is assumed that the maximum sag is the sag in the vertical plane. Designers must check the specified vertical clearance-to-ground for hillside terrain. See Annex B for an explanation of stress-strain characteristics and conductor sag.

A.5.2.3 Horizontal design clearances

Horizontal clearances for energized plant are based on the following:

- For conductors that are free to swing and are in the swing position as specified in Clause 5.2.7, the safe electrical component of the total clearance is taken as the switching surge withstand voltage of the air gap.
- For energized utility plant that is fixed (i.e., not free to move in the wind), the separation between live parts or between a live part and ground must withstand the switching surge voltage of the air gap.

A.5.2.5 Conductor temperature for thermal loading conditions

The thermal loading requirements are divided into three categories. In the first two cases, a specified wire or conductor temperature is used to determine maximum sag. The other case allows a utility engineer to calculate the conductor temperature for the purpose of determining maximum sag.

The maximum conductor temperature may be calculated using ANSI/IEEE-738. Also, it is intended that utilities be permitted to structure their maximum current to fit a variety of ambient conditions, provided that the resulting conductor temperature does not exceed the value that ensures that specified minimum clearances are met. It follows that short-term currents or emergency currents exceeding the maximum planned summer operating current may be carried, provided that they do not heat the conductor sufficiently to reduce the clearance below the specified minimum at the prevailing ambient conditions. Designers should ensure that, under emergency current conditions, the clearances specified in this Standard will be maintained.

Curves are included to show the conductor temperature rise above 40 °C ambient for various sizes of conductors (see Figure A.2).

Clause 5.2.5.2 does not preclude the planned summer operating of lines at currents exceeding rated ampacity, provided that the specified standard minimum clearances are met for the conductor temperatures calculated in accordance with Clause 5.2.5.2.

A.5.2.7 Wire or conductor swing for horizontal design clearances

The wire or conductor swing is based on a wind pressure of 230 N/m^2 on the projected area of the span of conductor. This represents a low-velocity wind of 18 m/s, considered to occur frequently enough to coincide with a switching surge overvoltage. (An air gap adequate to withstand the assumed value of switching surge voltage is added to the distance required for conductor swing.) The 18 m/s wind velocity is an empirical value; therefore, the 230 N/m^2 is used over the broad range of conductor sizes as a minimum value. In open terrain where severe winds occur, there can be situations where clearances might need to be increased for more severe wind conditions, but this is left to good practice.

The general formula for velocity pressure on wires is as follows:

$$P = C_d \times 1/2p \times V^2$$

where

P = velocity pressure, N/m^2

C_d = drag coefficient or shape factor

p = air density, kg/m^3

V = wind speed, m/s

Note: *Table 1 assumes a value of $C_d \times 1/2p = 0.719$.*

A.5.3 Vertical design clearances and separations

A.5.3.1 Vertical design clearances of wires and conductors above ground or rails and Tables 2 and 4

Particularly for transmission lines, utility Standards should provide margins both for the minimum clearance specified in this Standard and for the accuracy of field measurements (e.g., accuracy of surveying related to ground profile, accuracy of sagging and, where applicable, movement or settling of structures with time, as well as conductor creep).

The phrase "likely to be travelled by road vehicles" means areas over which road vehicles are normally expected to travel. While vehicles are physically able to travel over such locations as sidewalks, it is not normal for them to do so. It is not necessary, therefore, to provide clearances for vehicles over sidewalks, except at special locations such as sidewalks in front of loading platforms or driveways that cross sidewalks.

The phrase "normally accessible only to pedestrians" means walkways or other ground (such as parks) across which pedestrians normally travel. This category does not include areas of a bridge or building on which it would not be normal to expect a vehicle or person, or to swamps and areas that can only be crossed in winter.

The basic vertical clearance provided over a pedestrian way is 2.5 m for non-energized wires and grounded cables and 3.1 m for an energized open wire at a voltage of 750 V or less. An increment for voltage is added for conductors operating at greater than 750 V.

The basic vertical clearance over a roadway is 4.42 m at zero voltage. This clearance provides an additional 0.27 m over the maximum vehicle or load height permitted by most provinces. For energized ac and dc conductors less than or equal to 200 kV to ground, an increment for voltage is added. For ac conductors at voltages-to-ground greater than 200 kV, clearances are determined by calculated electrostatic induction or flashover requirements.

For energized conductors operating at 60 Hz voltages greater than 200 kV to ground and located so that they pass over or are adjacent to vehicles with large metallic surfaces, the clearance may be determined using calculated electrostatic induction requirements. This Standard is based on worst-case conditions, which assume that the vehicle is insulated from ground voltage by rubber tires and that a person contacting the vehicle is touching or standing on a well-grounded surface. Under these conditions, the minimum clearances specified in this Standard protect the public from harmful effects due to induced current that could flow from the vehicle to ground. This Standard is simplified to the extent that a fixed clearance value is specified for a given voltage level.

In actual practice, the tires on vehicles are conductive, and there is considerable leakage over the tires. In addition, the person contacting a vehicle is unlikely to be well grounded because of the resistance in his or her footwear and the fact that perfect grounding conditions are rare. The induced current in all practical cases is below the "5 mA let go" values that are documented in technical literature.

The clearance is evaluated as follows:

- For 200 kV or less to ground, the customary value for the increment is 0.01 m/kV.
- For greater than 200 kV to ground, electrostatic induction clearances are based on a large farm vehicle that is 7.6 m long, 2.4 m wide, and 4.15 m high, and a tractor-trailer that is 23.0 m long, 2.6 m wide, and 4.15 m high. Flashover calculations for low-induction vehicles are based on 0.01 m/kV for the

increment for a voltage greater than 200 kV. The electrostatic induction calculations are derived from "Field Effects of Overhead Transmission Lines and Stations".

Under normal line operating conditions, IEEE C95.6 requires that human exposure to electric fields be limited to 10 kV/m. This requirement is based on comfort rather than safety and assumes normal line operational conditions rather than maximum sag conditions, as used for Table 2. For voltage classes 200 kV and greater, the electric field under maximum sag conditions specified in Table 2 can exceed 10 kV/m. Consideration should be given to increasing the clearance where normal line operating conditions approach maximum conditions.

Sample calculations of clearances specified in Tables 2 and 4

The following examples illustrate the calculation of clearances in Tables 2 and 4, using the increment of 0.01 m/kV, where appropriate.

Example 1 — 230 kV phase-to-phase ac line

Switching surge voltage = 583 kV (from Table A.1)
Electrical flashover air gap (from Clause A.5)
= (2.54 mm/kV × 500 kV) + [3.81 mm/kV × (583 kV – 500 kV)]
= 1270 mm + 316 mm
= approximately 1.6 m

Applied to roads, the clearance requirement = 1.6 m + 4.1 m (truck height) + 0.3 m (added buffer) = 6 m. The minimum clearance specified in Table 2 for a 230 kV phase-to-phase ac line is 6.1 m.

Example 2 — 345 kV phase-to-phase ac line

Switching surge voltage = 840 kV (from Table A.1)
Electrical flashover air gap (from Clause A.5)
= (2.54 mm/kV × 500 kV) + [3.81 mm/kV × (840 kV – 500 kV)]
= 1270 mm + 1295 mm
= 2.56 m

Applied to roads, the clearance requirement = 2.6 m + 4.1 m (truck height) + 0.3 m (added buffer) = 7 m. Table 2 places a 345 kV nominal (380 kV maximum) line in the 220 kV rms line-to-ground category. The simplified calculation is as follows:
Clearance = 6.1 m + 0.01 m (220 – 150) = 6.1 + 0.7 = 6.8 m
While this value is less than the 7 m value calculated above, it is considered acceptable because the assumed surge overvoltage is a conservative value. Electrostatic induction at this voltage level for a tractor-trailer requires 10.2 m of clearance.

Example 3 — 735 kV phase-to-phase ac line (765 kV maximum)

Switching surge voltage = $\frac{765}{\sqrt{3}} \times \sqrt{2} \times 2.2$ = 1374 kV (from Table A.1)

Electrical flashover air gap (from Clause A.5)
= (2.54 mm/kV × 500 kV) + [3.81 mm/kV × (1374 kV – 500 kV)]
= 1270 mm + 3330 mm
= 4.6 m

Applied to roads, the clearance requirement = 4.6 m + 4.1 m (truck height) + 0.3 m (added buffer) = 9 m (clearance based on switching surge flashover).
Table 2 places 765 kV (442 kV voltage-to-ground) clearance at 20.4 m (clearance based on electrostatic induction), which is greater than the 9 m calculated value. Therefore, the 9 m clearance does not apply to clearances over roads. It applies to situations where electrostatic induction is not a factor.

Example 4 — 900 kV pole-to-pole (± 450 kV) dc line
Switching surge voltage = 720 kV (from Table A.2)
Electrical flashover air gap (from Clause A.5)
= (2.0 mm/kV × 144 kV) + [2.92 mm/kV × (720 kV – 144 kV)]
= 288 mm + 1682 mm
= 2 m

Applied to roads, the clearance requirement = 2 m + 4.1 m (truck height) + 0.3 m (added buffer) = 6.4 m. This value is considered low and, in view of the fact that the number of years of experience with, and testing of, dc lines at high voltages is small, 1.0 m has been added for a more conservative value. The minimum clearance specified in Table 4 is 7.4 m (6.4 m + 1.0 m).

The clearance over a driveway to a residence for an ac conductor of 0 to 750 V to ground is specified as 3.7 m at the maximum sag position. This is considered the minimum practical clearance, and does not include clearances for maximum truck height (4.1 m).

The clearance over a road for an ac conductor of 0.75 to 22 kV to ground is 4.1 m + 0.3 m + 0.3 m (electrical requirement) = 4.7 m. Table 2 specifies a minimum clearance of 4.75 m.

Historical railway standards specify a minimum vertical clearance requirement of 6.706 m (22 ft) above the top-of-rail level for beams, members, or portions of any bridge, tunnel, erection, or structure constructed for non-electrified lines after February 1, 1904. When the requirement was first established, one of the considerations was to provide safe clearance for a train worker standing on top of a freight car and signalling by hand or lantern, or both. Subsequent developments in railway operating practices, signalling methods, and sizes and types of rolling stock have made this practice obsolete, and the original minimum clearance requirement of 6.858 m (22 ft, 6 in) for rigid structures has been reduced to 6.706 m (22 ft) and is now relied upon to accommodate larger loads and special-purpose freight cars. The same minimum clearance requirement has been used for the *Canadian Electrical Code, Part III*, as the basic height to be protected for flexible structures such as conductors crossing over railway tracks, with additional allowances for safety and voltage.

The clearance over a railway track for an ac conductor of 0.75 to 22 kV to ground is calculated as follows:

- Basic height to be protected = 6.706 m
- Clearance = 6.706 m + 0.45 m (safety) + 0.3 m (electrical requirement) = 7.46 m.

Table 2 specifies a minimum clearance of 7.6 m.
An extra 0.3 m should be allowed for ballast where required (see Clause 5.3.1.1(c)).

The clearance for 0 to 750 V ac conductors over land, alongside roads and highways in rural areas, and within 1.5 m of the limit of the right-of-way, is calculated as follows:

- Clearance = 3 m (the protected height for a vehicle, e.g., a grass cutter, that is likely to be found on the unpaved portion adjacent to a fence) + 0.3 m (buffer) + 0.0001 m (electrical requirement) = 3.3 m.

Table 2 specifies a minimum clearance of 3.4 m.

At 22 kV, the specified clearance is less than that for roads that accommodate a 4.1 m high truck, but provides a larger buffer than that provided at 750 V.

- Clearance = 3 m (vehicle height) + 0.76 m (buffer) + 0.3 m (electrical requirement) = 4.1 m.

Table 2 specifies a minimum clearance of 4.15 m.
The same buffer is provided for conductors at higher voltages, which are not as likely to appear under these circumstances as are conductors of 0 to 750 V.

A simplified increment of 0.005 m for the voltage of dc conductors is used in Table 4. Using the air gap flashover data from Clause A.5 and two lines, one designated ± 200 kV and the other ± 450 kV, the following clearances are calculated:

- Switching surge voltage of ± 200 kV line = 320 kV to ground
  Clearance = (2.0 mm/kV × 144 kV) + [2.92 mm/kV × (320 kV – 144 kV)] = 802 mm

- Switching surge voltage of ± 450 kV line = 720 kV to ground
  Clearance = (2.0 mm/kV × 144 kV) + [2.92 mm/kV × (720 kV – 144 kV)] = 1970 mm

The difference in the two clearances = 1970 mm – 802 mm = 1168 mm or 1.17 m.

Using the increment of 0.005 m/kV, the difference in the two clearances = (450 kV – 200 kV) × 0.005 m/kV = 1.25 m.

A.5.3.2 Vertical separations (heights) of supply equipment from ground

Table 5 specifies minimum separations from ground of supply equipment mounted on poles. It does not refer to equipment in an enclosed substation. The specified separations of supply equipment from ground are minimum values. Utilities may increase the height, especially in areas such as farmyards, where hay racks or equipment of great height are commonly used.

A.5.7 Clearances of wires, conductors, and equipment from buildings, signs, bridges, swimming pools, and similar plant

The phrase "normally inaccessible", when applied to buildings, refers to those surfaces that cannot be reached easily without special aid (e.g., a ladder).

"Readily accessible surfaces" are those surfaces to which a person could normally gain access with no special effort (whether or not they are intended to be used by persons), such as windows, balconies, and flat roofs.

The horizontal clearance between a wire at zero voltage and a surface on a building should be such that, under a heavy wind, the wire will not be abraded by contact with the building. The clearances for energized conductors should be such that no flashover will occur under switching surge conditions. A buffer is added to provide for, among other things, the reach of a person located at a readily accessible point of the building.

Where an assessment of a particular condition calls for additional caution, greater clearances should be provided. Where extreme wind gusts are anticipated, extra clearances can be necessary, particularly in the lowest voltage categories. The clearances specified in Clause 5.7 are the minimum and should be increased where feasible.

Under maximum sag conditions, which are extreme conditions that arise infrequently, specified minimum vertical clearances provide a vertical space of 2.4 m or more to ensure that persons will have a reasonable degree of freedom to reach above head level. The electrical flashover component of clearance is generous, as it provides a switching surge withstand distance.

Clearances between oil and gas wells and associated drilling equipment from overhead supply lines are addressed in provincial regulations and are not covered in this Standard.

A.5.7.5 Minimum separation of equipment and clearances of conductors over and adjacent to swimming pools and Table 11

In general, conductors over swimming pools are undesirable for new construction. However, due to various conditions (e.g., limited lot size), it can be difficult to avoid this situation.

Clearances used in Table 11 have been determined based on the assumption that cleaning tools (up to 4.6 m in length) might be manoeuvred by inexperienced and/or young people.

A.5.7.6 Horizontal separations from supply equipment to buildings and Table 12

Horizontal separations for equipment attached to normally inaccessible surfaces of buildings provide a safe flashover distance. The separation for a readily accessible surface, where equipment is not attached to the surface, provides approximately 1 m for the possible reach of a person, plus a voltage increment.

A.5.7.8 Clearances from other flammable hazards

Clause 5.7.8 recognizes that open link fuse elements or other devices that can emit hot particles or glowing embers should not be installed over gas filling stations, fuel storage tanks, or other such installations.

A.5.7.9 Clearances for other wire facilities
The requirements of Clause 5.7.9 are derived from CSA Z98.

A.5.8 Clearances between wires and conductors of one line and wires, conductors, and structures of another line

A.5.8.1 Vertical clearances at crossings of line wires and conductors supported by different structures and Table 13
Where conductors cross each other, clearance has been provided to withstand the sum of the voltages between conductors, assuming a switching overvoltage on one line, normal operating voltage on the other line, and no sag in the lower conductor. Assuming no sag in the lower conductor provides for conductor jump (from ice shedding or galloping), which in short spans can reach the line of sight between structures. In rare instances, conductors have been reported to jump above the line of sight; however, the probability of a switching surge occurring on either line when this occurs is remote.

Furthermore, the probability of a switching surge occurring on both lines coincident with the upper conductor at maximum sag and the lower conductor at the line of sight is also considered extremely low.

Example 1 illustrates the method used to arrive at the clearances specified in Table 13:

Example 1

Assume an ac conductor in the 150 to 190 kV line-to-ground category crossing a conductor in the 50 to 90 kV line-to-ground category, with the switching surge voltage in the higher-voltage conductor.

- Line voltage of first line at 190 kV rms switching surge voltage
  $= 190 \times 1.414 \times 2.7$ (switching surge factor) $= 725$ kV
- Crest of peak voltage of second line $= 90 \times 1.414 = 127$ kV
- The air gap requirement for 852 kV (725 + 127 kV) is 2.54 mm/kV up to 500 kV plus 3.81 mm/kV over 500 kV $= (2.54 \times 500) + (3.81 \times 352) = 1270 + 1341 = 2611$ mm or 2.61 m.

Table 13 specifies a minimum clearance of 2.70 m.

Situations can arise whereby a line crosses over a long span of another line. Where the sag of the lower conductor exceeds 6 m at the point of crossing, it is unlikely that ice shedding or galloping will lead the lower conductor to reach the line of sight of the conductor.

The following examples show a 230 kV line (voltage-to-ground in the range of 120 to 150 kV) crossing over a 115 kV line (voltage-to-ground in the range of 50 to 90 kV) at two locations (see Figure A.3). The lower span is 300 m with a HAWK conductor.

To simplify the calculations in the examples, the ice- and wind-loaded sag of the bottom conductor is assumed to be in a vertical plane. This is in accordance with the definition of maximum sag.

When crossing over inclined spans, an additional check should be performed to ensure that the clearances specified in Table 13 are achieved with the upper conductor in a swing position and the lower conductor at rest.

Example 2 (see **Clause 5.8.1.1**)

In Figure A.3, the sag of the lower conductor is less than 6 m, so Clause 5.8.1.1 applies. Table 13 specifies a clearance of 2.1 m from the nearest upper conductor at maximum sag to the line of sight between the lower conductor supports.

Example 3 (see **Clause 5.8.1.2**)

The sag of the lower conductor for a HAWK conductor in a 300 m span is 8.94 m. The electrical clearance specified in Table 13 is 2.1 m. The reduction in clearances allowed by Clause 5.8.1.2 is calculated as follows:

$$\frac{(8.94 - 6)}{2} = 1.47 \text{ m}$$

Subtract 1.47 m from 2.1 m to obtain a clearance of 0.63 m. This is the distance by which the upper conductor must be above the line of sight of the lower conductor. In excessively long spans, the sag of the lower conductor can be much larger, and the values subtracted from Table 13 can yield a negative result. In such cases, the upper conductor can be below the line of sight of the lower conductor.

A.5.8.1.3 In-span vertical clearances between supply and communication conductors

Where supply and communication conductors cross each other, clearance is provided to ensure that they will not come in contact. Providing a midspan support structure with both the supply and communication conductors contacting the common structure results in

- ensuring that minimum in-span vertical clearances between the supply conductor and communication conductors, under conditions of maximum sag in the supply conductors as specified in Table 13, are met; and
- increasing the vertical clearance between the communication circuit and electric circuit under maximum load conditions, where required for additional safety (e.g., in flat-line construction).

In the event of contact between supply and communication cables, coordinated electrical protection should be used, with damage to either the supply or communication plant being kept to a minimum. This can be accomplished by one of the following two methods:

- Method 1 — prompt operation of protective devices provided in the supply plant. This is the preferred method.
- Method 2 — burn-off. Although burn-off may be used in certain situations, dependence on this method is not recommended. Where this method is used, safety must be enhanced and damage to the communication plant must be minimized.

In order for the electrical supply system to de-energize upon contact with the communication plant, the following conditions must be met or exceeded:

- Condition 1 — the maximum fault current on the supply system is equal to at least twice the minimum operating value of the supply system's protective devices controlling the sections where the supply and communication systems are in joint use (i.e., minimum melting current for fuses and minimum pick-up current for relays and reclosers).
- Condition 2 — the communication plant is bonded to a multi-grounded neutral of the supply system at 300 m intervals and at common crossing structures, using a minimum conductor size of No. 6 AWG copper or equivalent. In situations where the communication plant cannot be bonded to the supply multi-grounded neutral, the communication plant must be grounded with ground rods installed on both poles that support the communication wire crossing. Generally, a resistance of 25 Ω or less is recommended. If this cannot be achieved with a single rod, the rod may be coupled with another rod and driven deeper, or two ground rods may be installed, spaced at least 3 m away from each other, and aligned with the pole line.

Where supply and communication conductors cross each other, there are three options for safe installation:

- Option 1 — a common structure is installed, where practicable, at the point of crossing so that the supply and communications cable can be attached to the common crossing structure.
- Option 2 — where it is not practical to install a common structure, coordinated electrical protection is used.
- Option 3 — where coordinated electrical protection cannot be achieved due to the location of the wire crossings, a higher grade of construction is used to prevent future contact between supply and communication cables.

A.5.8.2 Clearances between conductors supported by different structures but not crossing each other and Table 15

The following examples illustrate clearances between conductors on different structures but not crossing one another. See also Figure A.4.

The minimum horizontal clearance between adjacent conductors A and B for a specific span in the line is calculated as follows:

- For line A, assume that the conductor sag plus insulator length at the 40 °C final unloaded condition is 3 m and that the d/w ratio is 22.4. From Table 1, the factor is 0.46 and the horizontal deviation is (0.46 × 3) = 1.38 m.

- For line B, assume that the conductor sag plus insulator length at the 40 °C final unloaded condition is 3.3 m and that the d/w ratio is 17.3. From Table 1, the factor is 0.38 and the horizontal deviation is (0.38 × 3.3) = 1.25 m.

Example 1
Where the structure of one line is opposite to the conductor of an adjacent line that is free to swing,
- the greater of the horizontal deviations = 1.38 m;
- the maximum voltage of line A = $\frac{127}{\sqrt{3}}$ = 73 kV to ground;
- the maximum voltage of line B = $\frac{253}{\sqrt{3}}$ = 146 kV to ground;
- the sum of these two voltages-to-ground = 73 kV + 146 kV = 219 kV;
- from Table 15, the clearance increment to be added to the horizontal deviation = 300 mm + (10 mm × 218.25) = 300 + 2183 mm = 2483 mm = 2.48 m; and
- the minimum horizontal clearance = 1.38 + 2.48 m = 3.86 m.

Example 2
Where the structures of each line are approximately adjacent to one another, the minimum horizontal clearance = (1.38/2) + 2.48 m = 3.17 m.

A.5.9 Separations of supply-line conductors and conductor supports on the same supporting structure

A.5.9.2 Vertical separations and clearances of supply-line conductors attached to the same supporting structure

A.5.9.2.3 In-span vertical clearances between supply-line conductors of the same circuit

Conductors of the same voltage class and belonging to the same circuit generally consist of 2- or 3-phase conductors of a primary voltage (i.e., greater than 750 V) or 2, 3, or 4 conductors of a secondary voltage (i.e., 0 to 750 V). Because they are of the same circuit, their sag at a given time is assumed to be similar.

The neutral of a primary voltage circuit is not normally at the same conductor temperature as the phase conductors, even where the neutral conductor size is reduced. This is usually due to the nature of the effectively grounded neutral and to the electric utility's efforts to maintain a balanced load on the circuit. Similarly, secondary voltage circuit conductors will not be at the same conductor temperature as their related primary voltage circuit conductors. Where the maximum sag of the upper primary voltage conductors is due to thermal loading conditions, experience suggests a neutral/secondary conductor design temperature of 40 °C. Where the maximum sag of the upper conductors is due to ice-loading conditions, experience suggests a neutral/secondary conductor temperature of 0 °C.

A.5.9.2.4 In-span vertical clearances between supply-line conductors of different circuits

Where conductors of one circuit are above those of another, it is reasonable to assume that the two circuits will not be at maximum sag at the same time. Experience suggests that the initial unloaded sag at the mean annual temperature is an appropriate worst-case design condition.

A.5.9.5 Separations or clearances in any direction from supply conductors to other supply plant attached to the same supporting structure

The highest voltage level in Table 22 is 50 kV, because it is recognized that at higher voltage levels there can be significant differences in switching surge levels, depending on system design. The inclusion of conservative increments above 50 kV could result in clearances that would require structural dimensions greater than those necessary for safe operation.

A.5.10 Joint-use clearances and separations — Supply and communication plant

A.5.10.1 Vertical separations at the structure — Normal level arrangement and Table 23

Figure A.5 illustrates the relative locations of supply and communication attachments on a joint-use pole where the normal level arrangement is used.

The minimum vertical separation required between supply and communication attachments on joint-use poles consists of a communication safety space, which varies with voltage and isolates the communication worker from electrical hazards, and a workspace to permit movement of a worker's body, tools, and work materials while working on the communication plant.

The minimum separations necessary to provide communication safety space for the voltage under consideration and to provide a workspace are given in Table 23. However, a company or utility may increase these separations where it believes additional workspace is necessary to ensure the safety of workers. Safety space is necessary for communication personnel safety.

It should be remembered that safety requires more than just space; it also depends on safe working practices. For example, stringing a communication strand under wires requires special precautions to ensure that the strand does not flip up into the communication safety space.

Live or current-carrying supply plant, including neutrals (see **Figure A.6**)

The separations specified in Table 23 provide the communication worker with a 0.75 m workspace below the appropriate communication safety space for the voltage under consideration. This workspace is adequate for normal operations, including the erection of a platform or tent on the communication strand. However, it is incumbent upon the communication worker to restrict work operations to locations below the bottom of the communication safety space.

Except where the voltage of the neutral conductor can be classified as 0 to 750 V in accordance with Clause 5.2.6, neutrals need the same clearance from communication plant as do their phase conductors because, during ground faults, neutrals that are not effectively grounded can approach phase voltage.

Lateral communication drops on line or run-off poles may be attached 0.6 m below 0 to 750 V supply plant. This location, which is above the uppermost longitudinal communication attachment, permits the communication worker to provide increased clearance over roadways as a public safety measure, since insufficient clearance could produce serious injuries or damage if a vehicle hits a drop and breaks a pole or breaks the drop and causes it to flip over supply circuits. When using this location, the worker must place his or her drive hook at eye level so as to remain within the normal workspace below the communication safety space. Workers also need to ensure that they do not obstruct the climbing space (see Clause A.4.1.4).

Non-energized supply plant

Option A (see Clause 5.10.1.6) applies where the communication utility necessitates normal workspace, usually to permit a tent or other form of covering to be used as protection against exposure to the weather during work operations. Where non-energized supply plant is effectively grounded, there is no provision for communication safety space. When it is not effectively grounded, however, it can become energized without warning, so the specified separation includes a communication safety space.

Option B (see Clause 5.10.1.7) — applies where communication workers are trained to work with not more than head and shoulders above the longitudinal communication plant. As with Option A, the separation specified for plant that is not effectively grounded includes a communication safety space. Where 0 to 750 V supply plant is effectively grounded, a separation of 0.10 m from communication plant is considered adequate for Option B. At voltages greater than 750 V, a separation of 0.30 m is considered necessary because the supply plant involved usually consists of large, heavy equipment such as a transformer, which needs a greater separation to facilitate installation and removal. This value should be increased wherever the minimum clearance between the conductors serving the transformers and the communication plant governs the design.

Trolley span wires or brackets (see **Figure A.7**)
The separation specified in Table 23 is provided to facilitate installation and removal. The requirements of Clause 4.2.11 ensure that the communication worker is isolated from electrical hazard.

Luminaire span wires or brackets (see **Clause 5.10.1.2** and **Figure A.7**)
This includes traffic lights and associated brackets (see Clause 4.2.10). Because the exposed metallic surfaces of ungrounded luminaires and associated brackets can become energized without warning, the vertical separation required from communication plant provides a communication safety space supplementary to normal communication workspace.

Point of attachment of combined communication drop and supply service conductor (see **Figure A.6**)
A combined service drop needs the same separation from longitudinal communication plant as would the supply service conductor by itself. The communication drop needs therefore to be separated from the supply service drop and extended down the surface of the structure into the communication workspace at any location where the communication worker has to work on it.

A.5.10.2.2 Wireless communication antenna

The separations specified in Clause 5.10.2.2 are based on the workspace needed by power line workers to safely install and maintain wireless antennas without having to de-energize the power lines. Occupational exposure to radiofrequency radiation from wireless communication antennas is addressed in Health Canada's *Safety Code 6.*

A.5.10.3 In-span vertical clearances and Table 24

Table 24 specifies a minimum 75 mm clearance under conditions of maximum sag in the upper conductor with little or no sag in the lower wire. The lower wire can be galloping, so that the highest point in the span is level with the points of support. An effectively grounded neutral needs less clearance than do the energized conductors.

A.5.11 Guys and guy attachments

A.5.11.2 Guys attached to joint-use structures and Tables 25 and 26

Where one utility places a guy on a joint-use pole for support of its attachments and where the guy runs near other systems not attached to the joint-use pole, the clearances in Table 25 apply, but clearances between this guy and circuits on the same structure are specified in Table 26. (See Figure A.8.)

A.7 Weather loads and assumed loads according to deterministic design methods

A.7.2 Weather loads

Heavy loading and medium loading A ice and wind combinations were adopted from earlier CSA Standards. Medium loading B was added to the 1976 edition of this Standard as an alternative to medium loading A for areas where greater ice loads and lower wind force are experienced. Severe loading was added in the 2001 edition.

The loading maps in Annex C are based on Environment Canada data and the experience of utilities across Canada. Designers are cautioned that these maps should be treated only as a guide and that local areas can have higher icing and/or wind forces. Conversely, there are local areas, such as laneways between tall buildings or along mountain valleys, where lines are sheltered from high winds. In these areas, transverse wind forces can be low, but "funneling" winds tend to be high in the longitudinal direction.

Designers unfamiliar with local weather conditions should acquaint themselves with the terrain and obtain local information from weather records and regional meteorologists. Where weather data are unavailable, local residents can be consulted.

Further data on ice and wind loadings can be obtained from Environment Canada.

A.7.3 Assumed loads for wire and cable attachments

The wind pressures specified in Table 30 (i.e., 400 N/m^2 and 300 N/m^2) correspond approximately to steady-state hourly wind velocities of 25 m/s and 21 m/s, respectively; these values are based on the formula provided in Clause A.5.2.7.

Maximum wind speeds are not generally associated with maximum icing. Greater wind speeds can occur on bare conductors, resulting in a greater transverse load than is incurred from the ice and wind combinations specified. This can occur when short spans and large-diameter conductors are employed. However, high winds generally occur over relatively narrow fronts. Where spans exceed 200 m, a reduction factor is frequently used to determine the resultant wind force over the entire span. This reduction factor varies with wind speed and terrain.

A.7.3.3

The 1.6 load factor approximates the ultimate strength of conductors when the maximum allowable tension of 60% is used.

A.7.4 General requirements — Loads on supports

A.7.4.2 and Tables 31, 32, and E.1

The load factors take into account the grade of construction and the type of material being used and the fact that weather loadings cannot be accurately determined. However, it should not be assumed that applying such load factors will completely eliminate the possibility of failure; therefore, these should be considered minimum values.

The load factors specified in Table 31 take into account the varying strength and COV of various materials and, to some extent, deterioration of the poles with age.

Table A.3 specifies the strength of various pole classes. The wood pole strengths are taken from CAN/CSA-O15 and the concrete pole strengths are taken from CAN/CSA-A14.

A.7.5 Assumed vertical load on supports

A.7.5.3 Assumed vertical load on crossarm assemblies, pins, posts, insulators, and fastenings

The additional load of 1.0 kN specified in Clause 7.5.3.1 is intended to represent the weight of a line worker.

A.7.6 Assumed transverse load due to wind pressure

A.7.6.2 Assumed transverse load on a structure

The loads specified in Clause 7.6.2 apply to structures not exceeding 30 m in height. Where structures are higher than 30 m, the wind forces on the structure should be determined by a more detailed assessment.

The 100% increase in wind pressure takes into account the approximate difference between round and flat surfaces due to the aerodynamics of wind flow. The designer is cautioned that the transverse wind forces on certain types of lattice structures can be greater when the wind direction acts at 45° to the transverse direction.

A.7.8 Assumed longitudinal loads on supports

The intent of this Standard is to ensure that there is sufficient longitudinal restraint built into tangent structures to minimize failures and to prevent cascade failure of adjacent structures in the line. In addition, dead-end structures should be designed to be capable of withstanding a theoretical unbalanced pull, independently, on each side of the structure.

With longitudinal restraint built into the dead-end structures, and with some degree of inherent longitudinal strength in most structures, there is no requirement to apply an assumed longitudinal load at tangent and angle structures in which the conductors are pin-connected or suspended, except where Grade 1 construction is required (see Clause 7.8.3).

A.7.8.2 Assumed longitudinal load on crossing or end structures where Grade 1 construction is called for in Tables 27, 28, and 29

Figures A.9 and A.10 and the following examples illustrate the application of loads and strength requirements for structures with pin-type construction at railway crossings.

For the following examples, it is assumed that

- N = 3 conductors, each with rated strength greater than 12.4 kN;
- T = 7.63 kN (maximum loaded tension per conductor, heavy loading);
- W = 14.59 N (horizontal wind force); and
- S = 76 m (average span length per m of conductor length)

Example 1 — Pole A, with a line angle of 20°

$$\text{Transverse and angle force} = \left(N \times 2 \times \sin\frac{A}{2}\right) + (N \times W \times S) + \text{wind on pole}$$

where

A = line angle

$$\left(N \times 2 \times T \times \sin\frac{A}{2}\right) = 3 \times 2 \times 7.63 \times \sin 10° = 45.78 \times 0.173 = 7.92 \text{ kN}$$

$N \times W \times S = 3 \times 14.59 \times 76$	= 3.33 kN
Wind on pole (assumed)	= 0.51 kN
Resultant force	≈ 11.76 kN

The strength requirements are calculated as follows:

- Angle — from the formula, the resultant transverse load at the angle structure is 11.76 kN. With a load factor of 2, a pole stronger than Class 1 is needed, so guying is necessary. The assumed horizontal loading on the guy(s) is 1.6 × 11.76, or 18.82 kN.
- Longitudinal — where the supply or communication lines adjacent to the crossing span are built to Grade 2 criteria or less, the assumed longitudinal load is taken as an unbalanced pull in the direction of the section requiring the stronger grade, in accordance with 33-1/3 percent of the sum of all the tensions, under loaded conditions [i.e., 33-1/3% x (3 × 7.63 kN) = 7.63 kN]. See Clause 7.8.2.3.

The centre phase conductor, which is approximately 0.3 m above the pole top, provides the maximum stress in the support. Where this load is transferred to 0.6 m below the pole top and a load factor of 1.5 is applied for an unguyed pole, the force is calculated as follows:

$$7.63 \times \frac{10.7}{9.8} \times 1.5 = 12.50 \text{ kN}$$

Table A.3 specifies that a Class 3 pole is needed to withstand this force. Where the pole is weaker than Class 3, it must be guyed away from the crossing span. Thus, where a pole weaker than Class 3 is used, it must be guyed in two directions, as shown in Figure A.10, for angle forces and longitudinal requirements.

Example 2 — Pole B

Transverse force = ($N \times W \times S$) + wind on pole
= 3.33 + 0.51
= 3.84 kN

The strength requirements are calculated as follows:

- Transverse — from the formula, the resultant wind force multiplied by a load factor of 2 is 7.68 kN. As specified in Table A.3, a Class 5 pole or better is needed, without guying. A lower class of pole needs to be guyed on each side in a transverse direction, as shown in Figure A.10.
- Longitudinal — the assumed longitudinal load calculations are the same as those determined for Pole A.

A.8 Strength of supporting systems according to deterministic design methods

A.8.1 General

Clause 8.1.2 explains the general application of load and strength requirements.

There are three categories or situations covered in Tables 27, 28, and 29: crossings, proximities, and joint use, respectively. A crossing can be formed quite simply by a single span (two structures) over a railway or road. In other cases, it can take many structures or spans to form a crossing (e.g., crossings over private or public property). Grade requirements apply to the entire section that forms the crossing, proximity, or joint-use situation. The only exception to this is the longitudinal load of Clause 7.8.2, which is applicable only where Grade 1 is required and in which case the additional strength requirements are supplied at each end of the Grade 1 section. Where Grade 2 or 3 is called for in Tables 27, 28, and 29, there are no longitudinal strength requirements, except where wire and cable attachments are terminated (i.e., dead-ended).

A.8.1.3

Clause 8.1.3 is not intended to permit the designer to neglect the eccentric forces on a structure that result from deformation, deflection, or displacement.

A.8.7 Supply conductors, supporting conductors, and messengers

A.8.7.3 Sags and tensions

In the process of designing overhead lines, tension limits of conductors are traditionally specified as a percentage of the conductor UTS. Invariably, these limits are intended to protect conductors from damaging aeolian vibrations and to provide enough safety margins to prevent conductors from breaking or overstretching under design ice and/or wind loads.

The percentages of UTS limits vary among countries and even among different provinces in Canada. The following limits are typical of many practices in various jurisdictions:

(a) Maximum conductor tension < 50 to 75% of UTS under design wind/ice loads/temperature. The purpose of this limit is to prevent conductor failure under extreme weather conditions as well as the occurrence of excessive plastic stretch when stresses are applied to conductors in the range of 80 to 95% of their UTS.

(b) Final bare conductor tension (without ice or wind loads) < 18 to 25% of UTS after the conductor has been subjected to long-term creep or permanent plastic deformation due to load. This and the following condition were meant to protect the conductor from fatigue failure due to aeolian vibration. The values of 18 to 25% of UTS were based on the assumption that conductors would be equipped with vibration dampers.

(c) Initial bare conductor tension < 20 to 35% of UTS when a new conductor is strung and sagged (prior to any long-term creep). This condition is similar to the previous one, except that it tends to protect the conductors from fatigue damage at the initial stage, a few months following the construction, when the conductor tension is high and long-term creep has not yet developed.

The limits specified above have been found to be acceptable in many countries and lines using mostly Aluminum Conductors Steel Reinforced (ACSR or A1/S1A in accordance with CAN/CSA-C61089) with a steel-to-aluminum ratio lower than 13%, as well as in the case of all aluminum conductors.

In past decades, many other conductor types and strandings have been used and it has been found that the above tension limits specified might not provide sufficient vibration fatigue protection for mixed conductors having a high steel ratio or for aluminum alloy conductors.

There is now a consensus among experts that the tension limit for controlling aeolian vibrations should not be based on a percentage of UTS, as in past practice, but rather on the value of the conductor catenary parameter C (m).

Note: *In case the conductor is loaded with wind and/or ice, the unit weight is replaced by the resultant load per unit length of the conductor.*

Recent overhead line design standards such as CSA C22.3 No. 60826 recommend the use of two principal conductor tension limits. The first limit applies to unloaded conductors and aims to prevent conductor fatigue due to aeolian vibration, while the second limit aims to prevent excessive conductor stretch due to the plastic deformation of the ice/wind-loaded conductor.

Because conductor tension varies with time due to long-term creep and the plastic stretch of the conductors related to ice/wind loads, there is also a debate about which conductor condition or catenary parameter should be used to control damaging aeolian vibrations. The recent study published in CIGRE Technical Brochure 273 proposes using the initial conductor tension at average temperatures of the coldest month as a basis for establishing the limits of the catenary parameter C.

Based on CIGRE Technical Brochure 273, limiting the initial conductor tension at average temperatures of the coldest month to a maximum value of catenary parameter C of 2000 m should be sufficient to reduce the chances of conductor fatigue due to aeolian vibrations when vibration dampers are used. Without vibration dampers, the same limit drops to between 1000 and 1400 m depending on terrain types. Because CIGRE Technical Brochure 273 does not propose any limit for the maximum conductor tension, the limit of 70 to 80% UTS specified in CSA C22.3 No. 60826 should be used. In this case, the tension should be calculated under the limit design loads used for the overhead line.

Note: *For design carried out in accordance with the working loads method, where a safety factor is imposed by the relevant standard/practice, the conductor tension under the combination of working loads, increased by the safety or overload factor, should not exceed a limit of 75 to 80% UTS.*

In addition to the above, it should be recognized that lines with short spans (i.e., 100 to 150 m, or less) do not benefit significantly from high conductor tensions or catenary parameters as do long spans (i.e., greater than 300 m). The table below provides the sags for a 1033.5 kcmil 54/7 "Curlew" ACSR conductor and two span lengths, both strung at C values ranging from 1000 to 2000 m.

Catenary parameter at –5 °C, initial conditions, m	Sag at 65 °C for 400 m span, m	Sag at 65 °C for 100 m span, m
2000	13.90	1.86
1800	14.59	1.96
1500	16.58	2.13
1200	19.29	2.32
1000	22.34	2.48

As specified in this table, the sag of the short span (e.g., distribution line) will increase only by 0.6 m when C is reduced from 2000 m to 1000 m, whereas the same reduction in C will increase the sag of the long span (e.g., transmission lines) by 8.5 m.

While the limit of C < 2000 m specified above provides a safe limit for vibration purposes, it might not be economical to use this limit for lines having spans less than 100 m. It should be recognized that, while increasing conductor tension reduces conductor sag, it will also increase loads on angle structures.

The following table illustrates the initial conductor tension as a percentage of UTS corresponding to the recommended catenary specified in Table 33 for various span lengths:

Span length, m	Recommended initial maximum catenary, m	Corresponding UTS for a 54/7 A1/S1A (ACSR) conductor, %	Corresponding UTS for a 45/7 A1/S1A (ACSR) conductor, %	Corresponding UTS for a 37 A1 (ASC) conductor, %	Corresponding UTS for a 37 A2 (AASC) conductor, %
> 400	2000	24	26	33	18
> 350 and ≤ 400	1900	22	25	31	17
> 300 and ≤ 350	1800	21	23	30	16
> 250 and ≤ 300	1700	20	22	28	15
> 200 and ≤ 250	1600	19	21	26	14
> 150 and ≤ 200	1500	18	20	25	13
> 100 and ≤ 150	1400	16	18	23	12
≤ 100	1300	15	17	21	11

A.8.12 Paired communication conductors — Grades 1 and 2

A.8.12.2 Paired conductors not supported by messengers — Grades 1 and 2

Clause 8.12.2 accounts for new communication conductors that incorporate tensile members as an integral part of the jacket.

A.9 Grounding methods for supply systems less than or equal to 22 kV and communication facilities

A.9.1 Supply systems less than or equal to 22 kV

A.9.1.2 Ground resistance requirements

A.9.1.2.1 Multi-grounded systems

A.9.1.2.1.1

Due to the vast differences between utility practices, customer load conditions, and geographical soil conditions, it is often impossible to establish a level of steady-state neutral-to-earth voltage that can satisfy the safe let-go current value specified in IEEE 80 at all locations within a distribution system. Different measures or practices may be adopted by utilities to prevent possible electric shock hazards to persons, rather than trying to lower the neutral-to-ground voltage to a specific value at all points in the distribution system. For example, isolating the primary neutral from the secondary neutral prevents the passage of excessive voltage to a consumer's premises.

A.9.1.2.1.2

This Clause is intended to address the potential hazard arising from isolated sections of multi-grounded neutral systems situated in the same general vicinity. In some regions, it is common practice that two separate subdivisions (of the same municipality) are developed at different times but are fed by the same earth return 3-phase feeder. Each of the subdivisions is served by its own multi-grounded neutral system, but the neutral conductor does not extend beyond the subdivision boundary.

Over time, these two subdivisions will expand and eventually meet. As the physical distance between the subdivisions is reduced, the probability of the two subdivisions being bridged by a telecommunication conductor increases. It is thus important to ensure that the system neutral conductors of the two subdivisions are connected to prevent damage to the communication sheath and communication equipment due to a line-to-ground fault. Although the system neutral is not connected between the two subdivisions, bonding of the system neutrals might already be in place through the communication cables. During a line-to-ground fault, the fault current might flow back to the source through the sheath of the communication wire, potentially causing damage to communication equipment. It is thus crucial to ensure there is a continuous low-impedance path for the flow of fault currents.

A.9.1.2.2 Earth return systems

For an earth return system, the fact that all neutral return current flows through the ground electrode (as compared with neutral conductors for a multi-grounded neutral system) means that the heating effect of the ground electrode by the return current warrants special attention. A maximum of 5 A return current may typically be used for each deep-driven electrode or set of multi-rod electrodes under steady-state conditions.

Neutral return current is calculated in accordance with the following:

- For a single-phase load of 50 kVA on a 24940GrdY/14400 V system, neutral return current is 3.5 A. One set of ground electrodes and one set of redundant ground electrodes are necessary.
- For a balanced 3-phase load, there is no neutral return current. The neutral return current for 3-phase transformers depends on the amount of unbalanced load.
- For regulator banks, the neutral return current depends on the tap changer positions of all three phases. For example, a 100 A single-phase regulator with ±10% tap changer will have 10 A neutral return current at maximum boost position.

  Note: *The polarity of the neutral current reverses when the tap changer changes from buck to boost position. As a result, the neutral return current of a* 100 A *3-phase regulator bank with ±10% tap changer under the worst condition can be* 20 A *(one phase under full buck position and the other two phases under full boost position).*
- For 3-phase capacitor banks without unbalanced protection, the neutral return current is the phase current. For 3-phase capacitor banks with unbalanced protection, the neutral return current is the trip setting of the unbalanced protection.

The ground electrode is surrounded by earth that is made up of concentric shells of equal thickness. Those shells closest to the ground electrode have the smallest amount of area, resulting in the greatest degree of resistance. Each subsequent shell incorporates a greater area, resulting in lower resistance, so that, eventually, additional shells offer little resistance to the ground surrounding the ground electrode.

A deep-driven ground electrode is generally more effective at lowering the ground resistance due to the long cylindrical shape of the shells. Where several ground electrodes are used to lower ground resistance, each ground electrode has its own sphere of influence. Without proper spacing of the ground electrodes, the spheres of influence intersect and the lowering of ground resistance is minimal. Thus, for additional electrodes to be effective, the spacing of additional rods needs to be at least equal to the depth of the driven rod.

Redundancy of ground electrodes should be ensured for earth return systems. If the connection of one ground electrode is broken for any reason, the transformer primary neutral floats at the phase voltage. To avoid this potentially hazardous situation, redundant ground electrodes and ground wire connections should be installed as close as practicable to the transformer primary neutral connection. Redundancy of ground electrodes is provided by installing an extra set of ground electrodes at a minimum distance of 10 m from the first ground electrode or, alternatively, at the adjacent pole. The 10 m distance is used to minimize the heating effect of the neutral return current through the ground electrode. The two sets of ground electrodes are interconnected by overhead conductors or buried ground wire.

Redundant ground wire connection can be provided by installing separate ground wires on separate poles, or on opposite sides of the same pole where the ground wires are on the same structure. The intent of this measure is to reduce the likelihood of damaging both wires at the same time.

Table A.1
Switching surge values for ac conductors

(See Clause A.5.)

Nominal system voltages, kV phase-to-phase*	Maximum line-to-ground voltage, kV	Equivalent phase-to-phase voltage, kV	Switching surge factor	Switching surge crest voltage, kV	Flashover-to-ground distance, mm
—	0.75	—	—	—	8
4, 8	5	8.7	4	—	72
12, 13.2	10	17.4	4	—	144
25	15	26	4	—	216
34	22	38	4	—	316
66, 69	50	87	4	283	718
115, 132	90	155	3	382	970
161	120	208	2.75	467	1185
230	150	260	2.75	583	1586
287, 300, 315	190	329	2.7	725	2129
345, 360	220	380	2.7	840	2566
400	250	433	2.7	954	3000
500	318	550	2.5	1122	3640
735	442	765	2.2	1374	4600

**There can be more than one nominal voltage.*

Table A.2
Switching surge values for dc conductors

(See Clause A.5.)

Maximum line-to-ground voltage, kV	Maximum system voltages, kV	Switching surge voltage (line-to-ground voltage × 1.6), kV	Flashover-to-ground distance, mm
200	± 200	320	802
250	± 250	400	1036
300	± 300	480	1269
350	± 350	560	1503
400	± 400	640	1736
450	± 450	720	1970

Note: *The following examples illustrate the calculation of switching surge voltages in Tables A.1 and A.2:*

(a) ac nominal system voltage = 230 kV
Maximum phase-to-phase voltage = 230 kV + *10%*(230 kV) = 253 kV
Equivalent line-to-ground voltage = 253 kV ÷ $\sqrt{3}$ = 146 kV
This falls in the range of > 120 kV *and* ≤ 150 kV.
Switching surge factor = 2.75
Switching surge crest voltage = 146 kV × $\sqrt{2}$ × *2.75* = 568 kV

(b) ac nominal system voltage = 500 kV
Maximum phase-to-phase voltage = 500 kV + *10%*(500 kV) = 550 kV
Equivalent line-to-ground voltage = 550 kV ÷ $\sqrt{3}$ = 317.5 kV
Switching surge factor = 2.50
Switching surge crest voltage = 317.5 kV × $\sqrt{2}$ *2.5*×= 1122 kV

(c) dc voltage = ±450 kV
Assume that 450 kV *is the maximum pole voltage under steady-state conditions.*
Maximum phase-to-ground voltage = 450 kV
Switching surge voltage = *1.6* × 450 kV = 720 kV

Table A.3
Pole classes and strengths

(See Clauses A.7.4.2 and A.7.8.2.)

Class		Ultimate strength horizontal force (applied 0.6 m from top of pole), kN
Wood	Concrete	
1	J	20.0
2	H	16.5
3	G	13.3
4	F	10.7
5	E	8.5
6	D	6.7
7	C	5.3

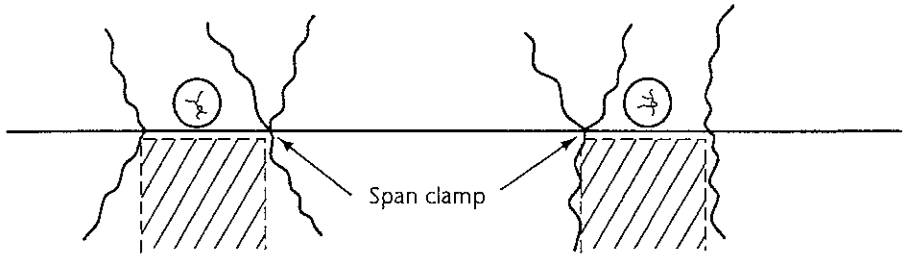
Table A.4
Damage and failure limits of structures

(See Clauses 8.3.8.1, 8.3.9, 8.3.10.1, and 8.3.12.3.)

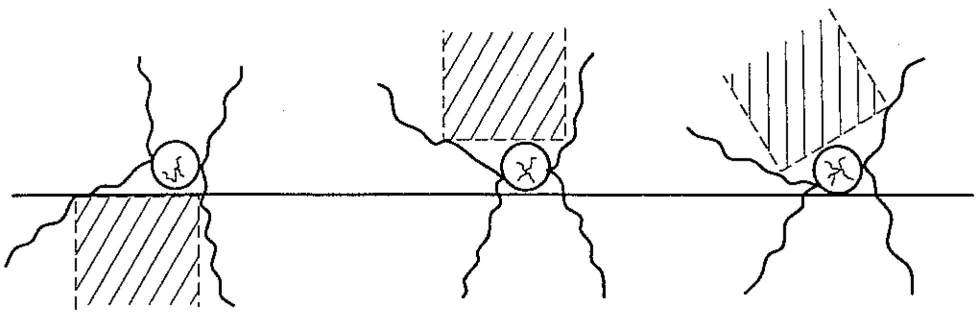
Supports				
Support type	**Material or elements**	**Loading mode**	**Damage limit**	**Failure limit**
Lattice tower (including guyed towers)	All elements except guys	Tension	Yield (elastic) stress	Ultimate tensile (breaking) stress
		Shear	90% (elastic) shear stress	Shear (breaking) stress
		Compression (buckling)	Non-elastic deformation* from L/500 to L/100	Collapse by instability
	Steel guys	Tension	Lower value of (a) yield stress (70% to 75% UTS); and (b) deformation corresponding to a 5% reduction in the tower strength	Ultimate tensile stress
Poles	Steel	Moments	1% non-elastic deformation at the top, or elastic deformation that can impair clearances	Local buckling in compression or ultimate tensile stress in tension
		Compression (buckling)	Non-elastic deformation from L/500 to L/100	Collapse by instability
	Fibre-reinforced composite	Moments	Elastic deformation that can impair clearances	Local buckling in compression
		Compression (buckling)	Deflection at pole mid-section	Collapse by instability
	Wood	Moments	3% non-elastic displacement at the top	Ultimate tensile stress
		Compression (buckling)	Non-elastic deformation from L/500 to L/100	Collapse by instability
	Concrete	Permanent loads and non-permanent loads	Crack opening† after release of load or 0.5% non-elastic deformation	Collapse of the pole

**The deformation of compression elements is the maximum sag from the line joining end points. For elements subject to moments, it is the displacement of the free end from the vertical.*
†The width of crack opening is subject to agreement between manufacturer and purchaser.
Note: *L = length of the element.*

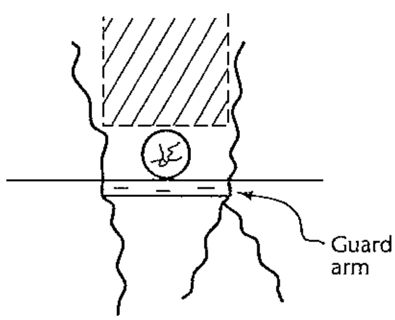
Method 1
When cable strand is available in the span, distribute drops from span clamps.



Method 2
When cable strand is not available in the span, distribute drops directly from pole.



Method 3
When climbing space cannot otherwise be achieved on either the field or street side of the pole, place a guard arm on the pole and distribute drops from the guard arm.

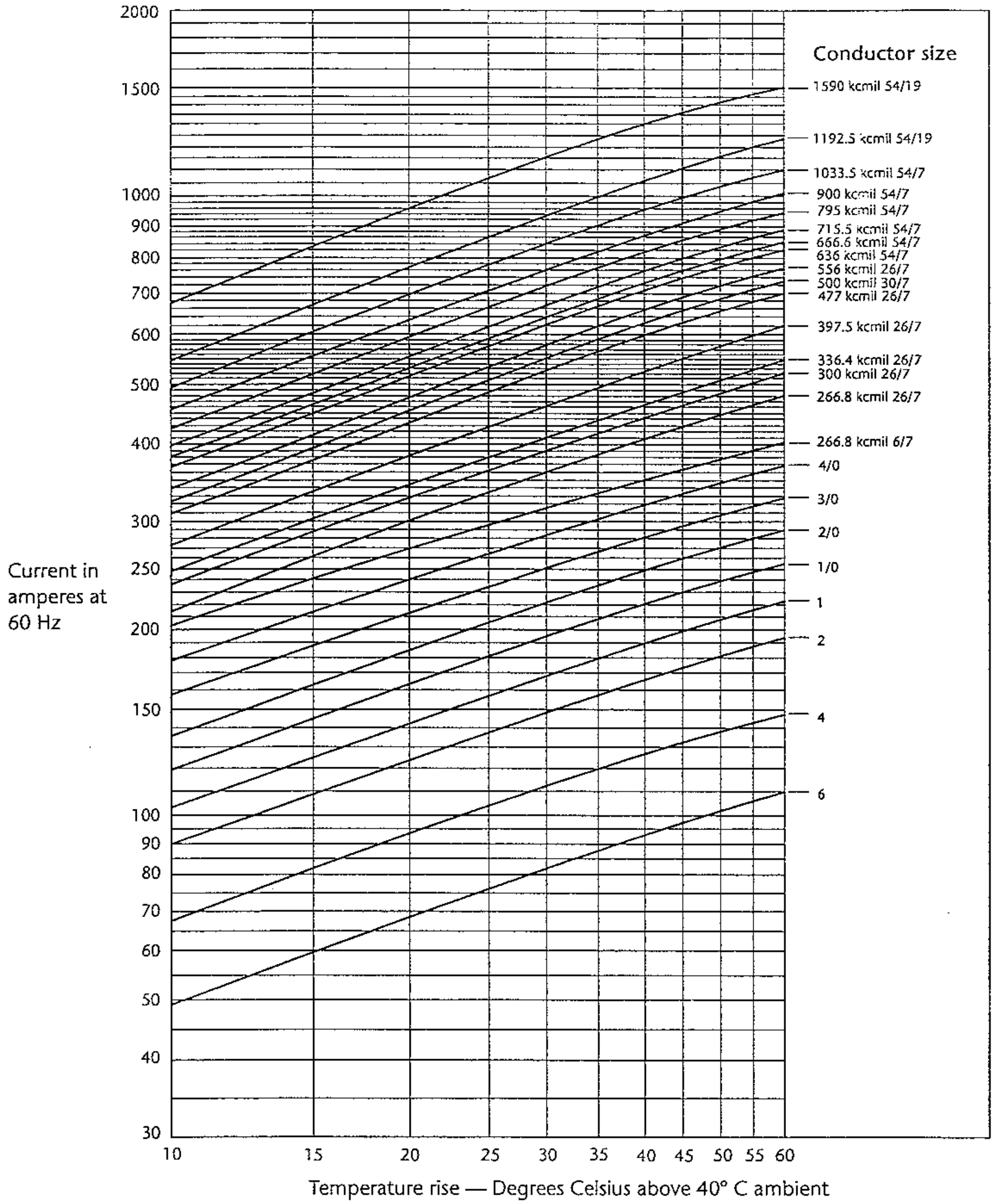


Legend:

= joint-use pole
= line conductor
= lateral drop wire
= minimum climbing space (0.75 m × 0.75 m)

Note: *Climbing space should be on the road side or field side of the pole.*

Figure A.1
Examples of climbing space involving drop wires
(See Clause A.4.1.4.)



Notes:
(1) *Air velocity = 0.61 m/s crosswise to conductor.*
(2) *Emissivity = 0.5.*
(3) *No sun; at sea level.*
(4) *Ambient temperature = 40 °C.*

Figure A.2
Example of temperature rise curves of Canadian standard sizes ACSR — Bare
(See Clause A.5.2.5.)

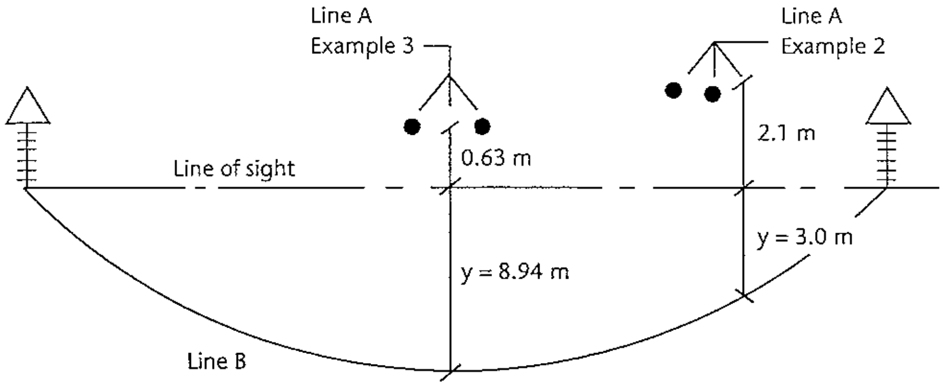


Figure A.3
Vertical clearances at conductor crossings
(See Clause A.5.8.1.)

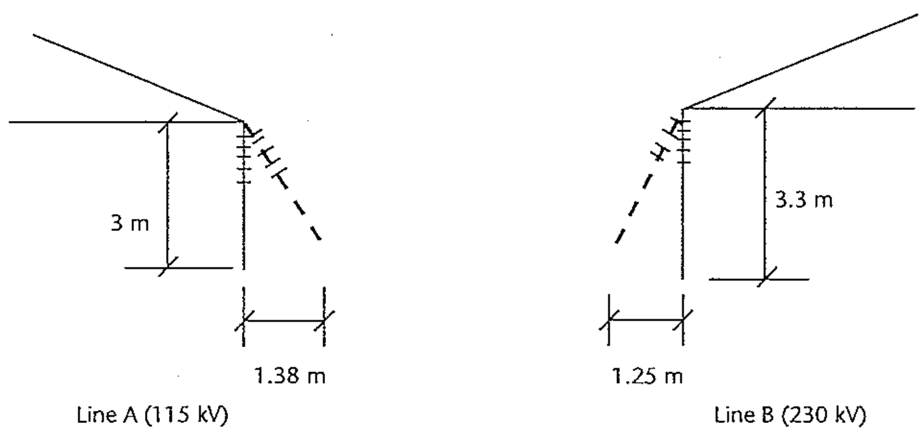


Figure A.4
Horizontal clearance between conductors on different structures
(See Clause A.5.8.2.)

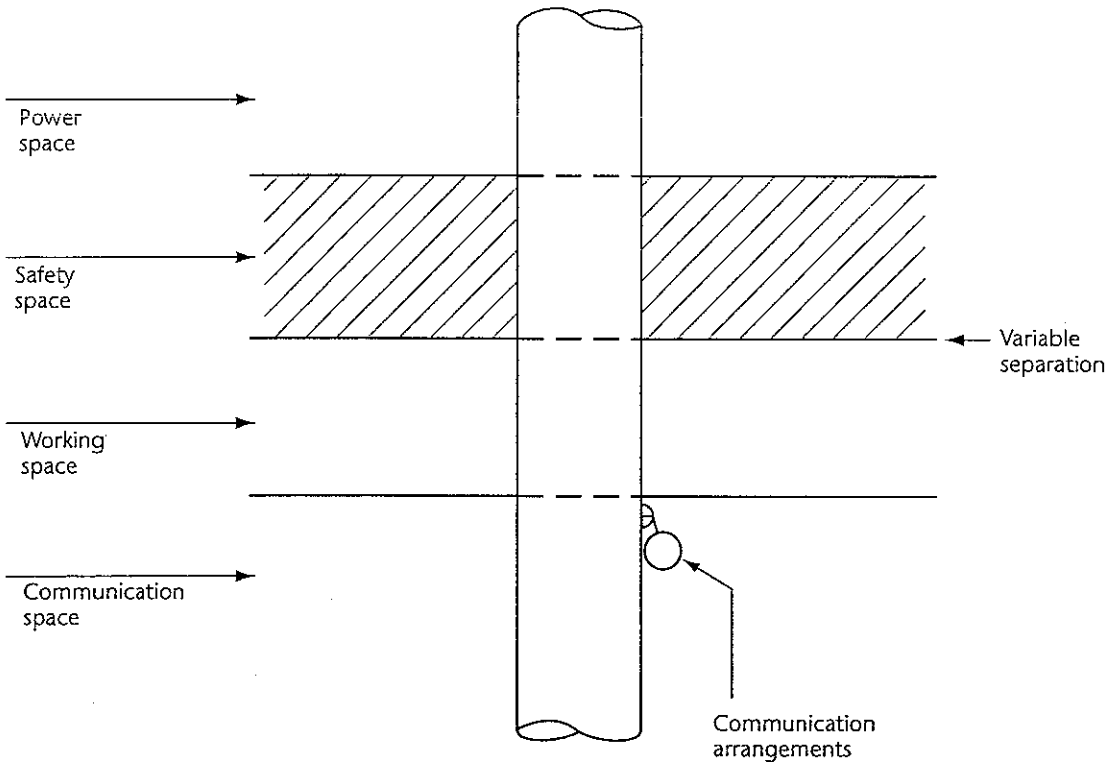
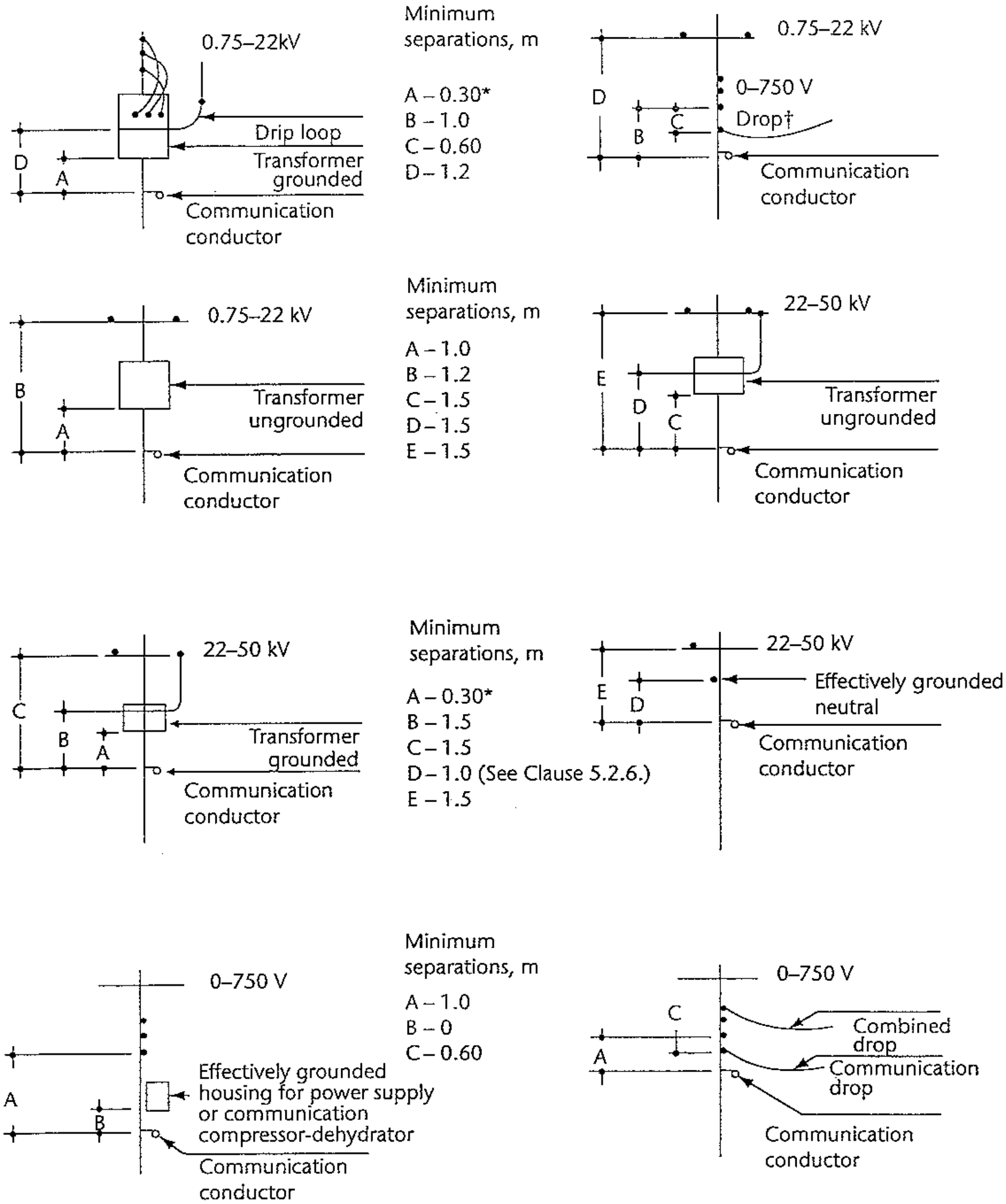
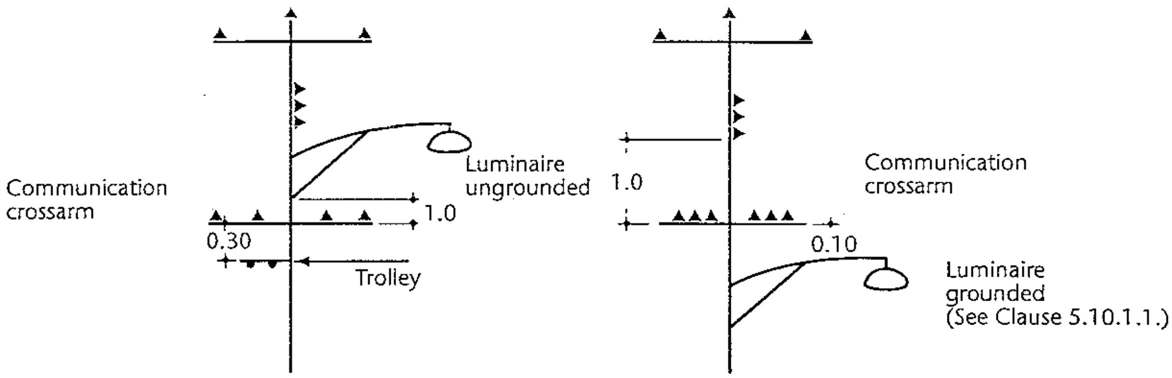


Figure A.5
Joint-use pole spaces
(See Clause A.5.10.1.)

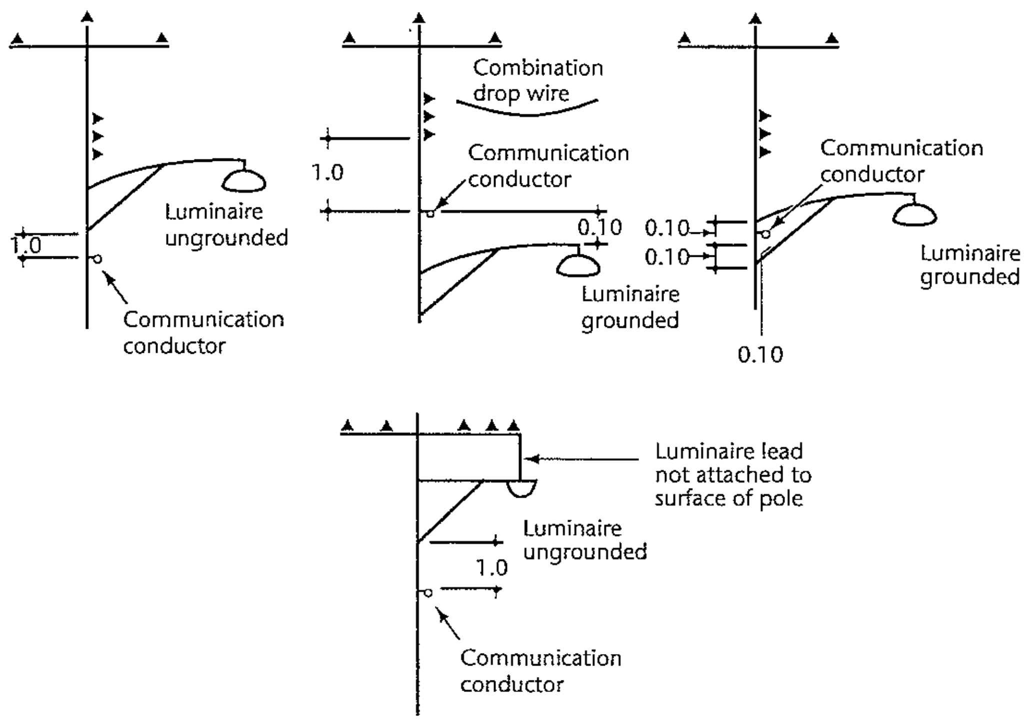


*Where working space is needed for a tent (Option A), the minimum separation is increased to 0.75 m.
†Working space needed for drop.

Figure A.6
Illustrations of the minimum vertical separations specified in Table 23
(See Clause A.5.10.1.)



(a) Separations to communication crossarms for luminaires operating at 0–750 V — Luminaire leads in cable on surface of pole



(b) Separations to cable or paired wire from luminaires operating at 0–750 V — Luminaire leads on surface of pole

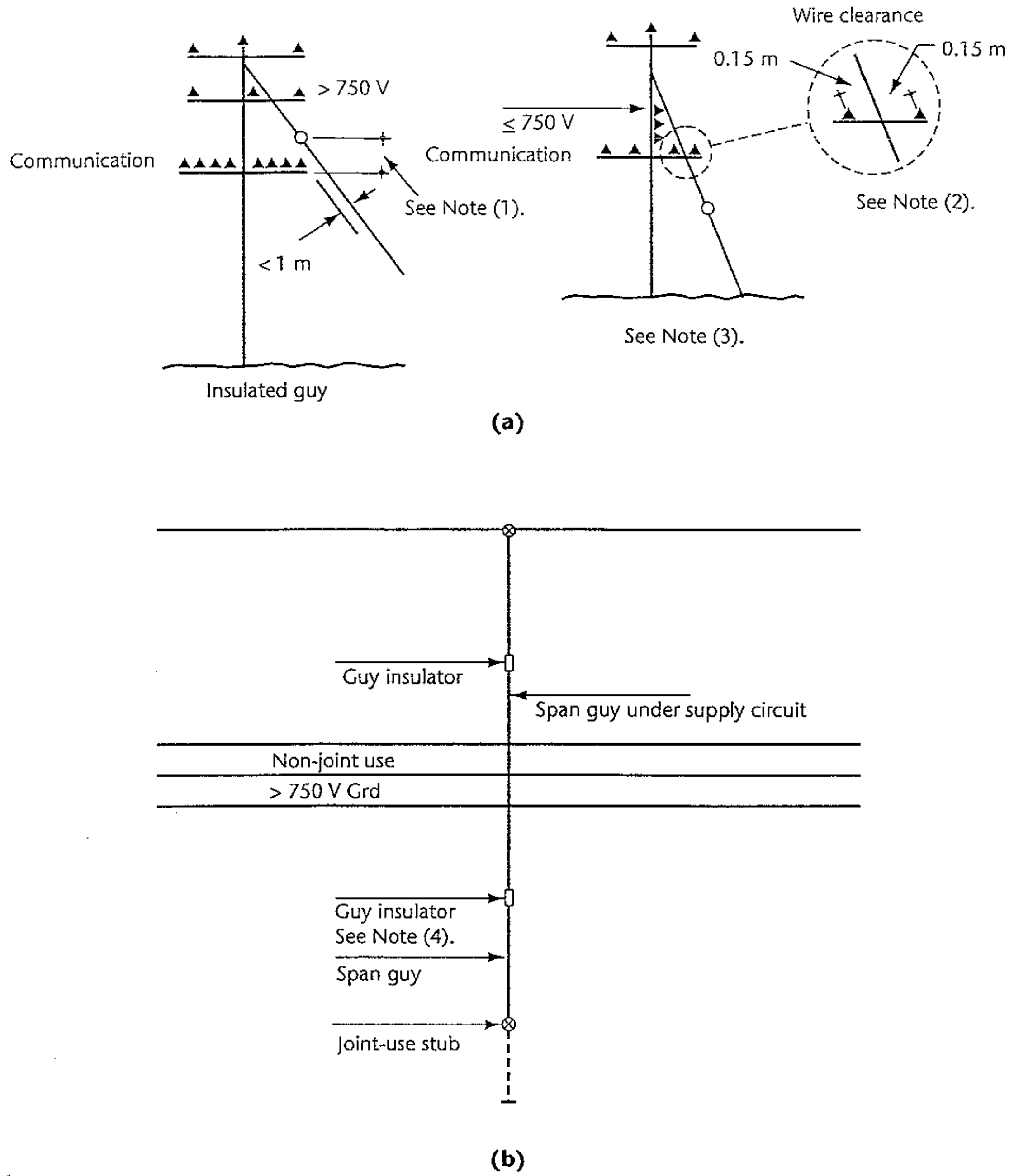
Notes:

(1) *All values given are in metres unless otherwise specified.*

(2) *All values given are minimum separations.*

Figure A.7
Illustrations of the minimum vertical separations specified in Table 23

(See Clause A.5.10.1.)



Notes:

(1) *This Standard does not specify a distance between communication plant and a guy insulator. A minimum clearance of 102 m should be used to provide safe clearance when working on communication plant (see Clause 5.11.4).*

(2) *Where a guy is attached above supply conductors less than 750 V to ground, no insulator is required above communication equipment and one guy insulator is sufficient below communication equipment.*

(3) *Communication pin space might have to be rearranged.*

(4) *Guy insulators need to be appropriate for line voltage.*

Figure A.8
Illustrations of minimum clearances for guy insulators as specified in Tables 25 and 26

(See Clause A.5.11.2.)

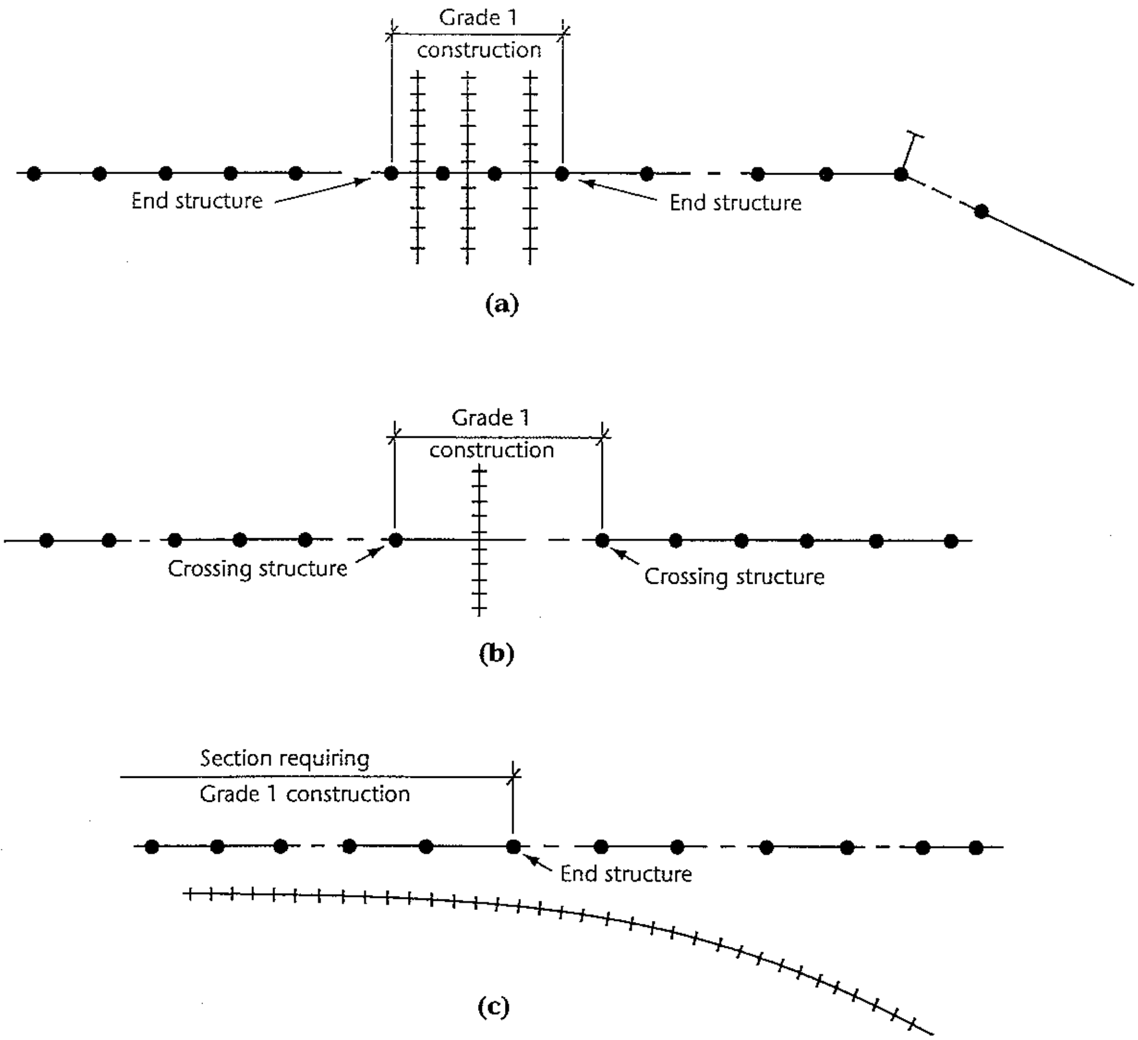


Figure A.9
Crossing or end structures
(See Clause A.7.8.2.)

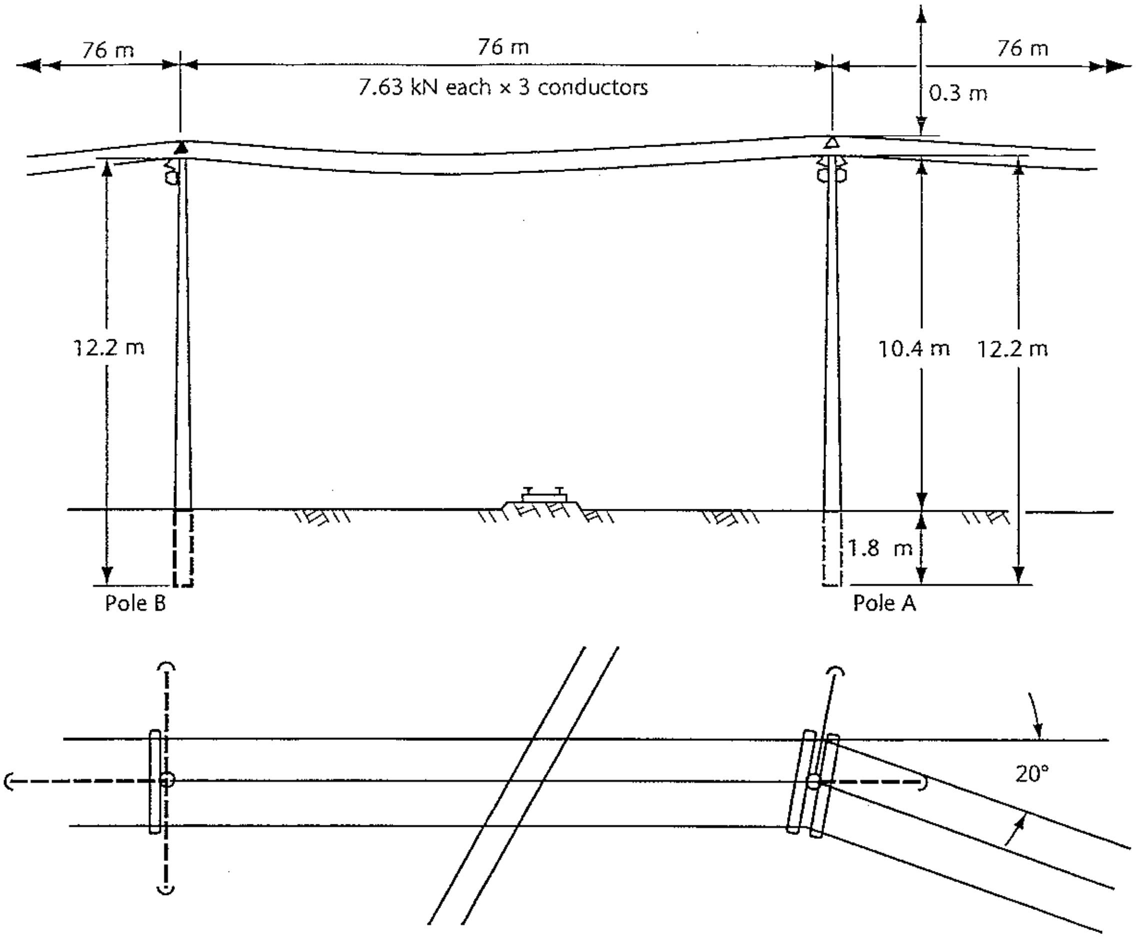


Figure A.10
Railway crossing
(See Clause A.7.8.2.)

Annex B (informative)
Stress-strain characteristics and conductor sag

Note: *This Annex is not a mandatory part of this Standard.*

B.1 General

The purpose of this Annex is to illustrate the various sag and tension definitions used in this Standard.

B.2 Stress-strain characteristics

B.2.1

Conductor material such as hard-drawn copper is partially elastic. Thus, when an unstressed length of the wire is subjected to a certain tension, it will elongate to a length greater than the original unstressed length. When the tension is removed, the wire will contract to a length that is between the stressed and original unstressed lengths. The difference between the original unstressed length and the intermediate length is due to non-elastic elongation, whereas the difference between the stressed length and the intermediate length is due to elastic elongation. In other words, the elastic stretch is recovered when the tension is removed but the non-elastic stretch is not. If, upon removal of the tension, the wire contracts to the original unstressed length, there is no non-elastic elongation or permanent stretch, and the material is perfectly elastic.

B.2.2

The stress-strain characteristics of a conductor are illustrated in Figure B.1, which assumes that the conductor is of one metal only. A composite conductor such as ACSR would have a somewhat more complicated stress-strain characteristic, owing to the presence of two metals with dissimilar elastic properties.

Figure B.2 shows a conductor of the original unstressed length, L, strung up between supports A and B, which in this example are assumed to be at equal elevations. This conductor is subjected to the initial or stringing tension, T_1. In order to avoid the necessity of considering temperature changes, which would introduce further expansions and contractions of the conductor, it is assumed that the temperature remains constant at −18 °C.

Figure B.1 shows that tension T_1 is associated with point "a" on the curve, and that the wire has stretched from its original length, L, to a new length equal to L plus the stretch represented by the per cent elongation e_2. If the wire were taken down again and measured, it would be found to be longer than L by an amount corresponding to the per cent elongation e_1 (i.e., by the amount that has been referred to as non-elastic stretch).

Similarly, the loading of the conductor with ice increases its tension to a new value, T_2, resulting in the position indicated by the lowest of the three catenary curves in Figure B.2. This tension corresponds to point "b" in Figure B.1, and the stressed length of the conductor is now equal to L plus the stretch corresponding to per cent elongation e_3. If the ice loading is removed from the conductor, its tension will reduce to T_3, and it will take up a position indicated by the intermediate catenary curve of Figure B.2. The length of this catenary is smaller than that of the lowest catenary and is given by L plus the stretch associated with per cent elongation e_4. This corresponds from point "b" to point "c" along a line generally parallel to the line connecting point "a" with per cent elongation e_1. If the wire is taken down again and measured, it will have an unstressed length equal to L plus the stretch associated with per cent elongation e_5. In other words, the application of the ice load has introduced additional non-elastic stretch in the conductor over the amount that resulted from the stringing tension T_1; that is, the non-elastic elongation has been increased from e_1 to e_5.

If the wire is left in place when it reaches point "c", subsequent loadings will move it up and down along the b–c line, provided that no tension greater than T_2 is experienced. This b–c line is approximately straight, indicating that once the wire is subjected to its maximum load, it is considered to be perfectly elastic.

B.3 Horizontal spans

Changes in temperature are accompanied by expansions or contractions in the length of a conductor. Figure B.3 shows a conductor strung by the "Initial (a) 16 °C" catenary, which is then subjected to code loading that brings it down to the catenary marked "Final loaded (heavy)". Removal of this load and return to a temperature of 16 °C bring the conductor back to the catenary marked "Final unloaded 16 °C", which lies between the initial and final loaded positions. If the temperature is varied, the conductor will assume other positions, such as those indicated for final unloaded sag at –18 °C, 49 °C, or 93 °C. In certain cases, the final unloaded sag for 93 °C will be greater than the final loaded sag, as shown in Figure B.3. Similarly, final unloaded sag for –18 °C can sometimes be less than the initial sag at 16 °C, as indicated by the dotted catenary marked "Initial (b) 16 °C".

Assuming that Figure B.2 shows the upper catenary in the initial position at 16 °C, the lower catenary in the final loaded position (either medium or heavy loading), and the intermediate catenary in the final unloaded position at 16 °C, the three centre-span sags (assuming A and B to be at equal elevations) may be termed, reading from top to bottom,

(a) initial unloaded sag at 16 °C;
(b) final unloaded sag at 16 °C; and
(c) final loaded sag (heavy or medium).

The final loaded sag minus the final unloaded sag is called the sag increase. Since the final unloaded sag can be at various temperatures, it is convenient to designate the sag increase by the temperature at which the final unloaded sag is given, as follows:

sag increase = final loaded sag (°C) – final unloaded sag (°C).

Note that where the final unloaded sag is greater than the final loaded sag, as for 93 °C in Figure B.3, the sag increase calculated using this formula will be negative. This situation occurs only with large conductors, but is possible for all lines. The minimum clearance values specified in this Standard are intended to accommodate this situation.

In this Annex, each span is assumed to be dead-ended, for the sake of simplicity. Situations involving a line containing spans of different lengths are ignored in order to avoid a discussion of the problem of ruling spans. The sag phenomena of dead-ended spans also apply to ruling spans, though the details will vary.

When a specific conductor is strung in a dead-ended span such that the tension in the conductor under the final loaded condition is 60% of the breaking strength, the sag increases vary according to the span length. A typical graph of sag increase versus span length is shown in Figure B.4. Each curve in Figure B.4 is calculated for a different percentage of breaking strength under the final loaded condition, and all curves have a characteristic shape. The sag increase peaks at a different span length for each curve. For span lengths greater than those associated with the peak, the sag increase drops off in value. The peak value of sag increase is usually termed the "maximum sag increase" and should be associated with a given size and type of conductor, span length, temperature for final unloaded sag, percentage of breaking strength in the final loaded condition, and final loaded condition (e.g., medium or heavy).

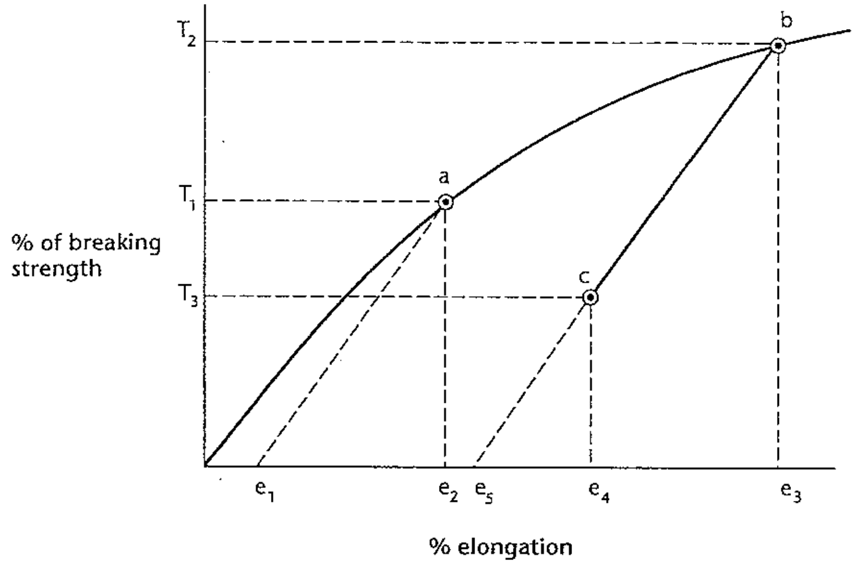


Figure B.1
Stress-strain graph
(See Clause B.2.2.)

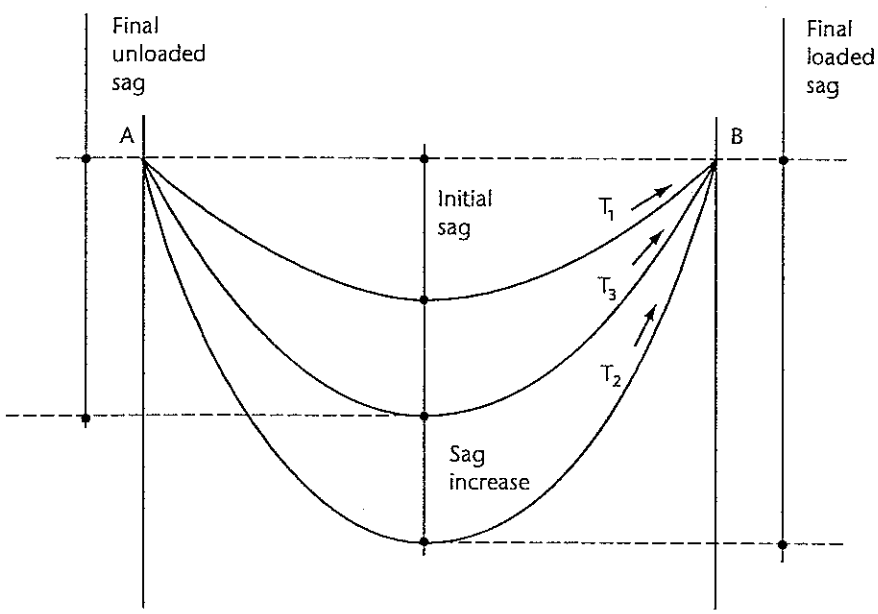


Figure B.2
Sag diagram — Constant temperature
(See Clauses B.2.2 and B.3.)

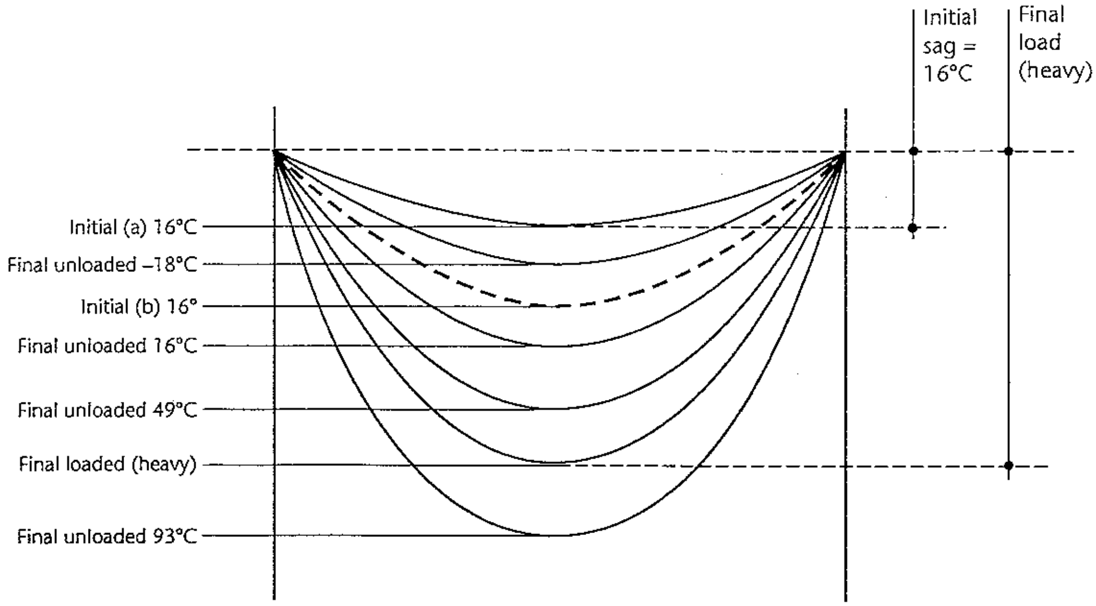
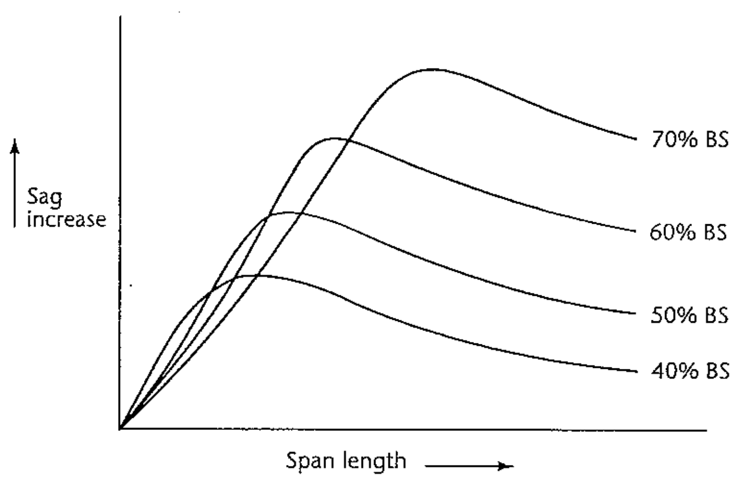


Figure B.3
Sag diagram — Variable temperature
(See Clause B.3.)



Note: *BS = breaking strength.*

Figure B.4
Sag increases vs. span length
(See Clause B.3.)

Annex C (informative)
Loading maps

Note: *This Annex is not a mandatory part of this Standard.*

Figure C.1
Loading map of Canada
(See Clause 7.2 and Table 30.)

```
ERROR: limitcheck
OFFENDING COMMAND: stroke

OPERAND STACK:
```

This is **EXHIBIT "H"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Questions

1. Please provide the following information on permit applications for wireless attachments to the poles of Ontario electricity distributors for the purpose of operating the distributed antenna systems ("DAS") network:

    1.1 Total number of permit applications that have been made to each Ontario electricity distributor broken down by distributor.

    1.2 Number of applications that have been processed by each Ontario electricity distributor.

    1.3 Number of attachment permits that have been granted by each Ontario electricity distributor.

    1.4 Number of attachment applications that (a) have not been processed; or (b) rejected by each Ontario electricity distributor and reasons given by each distributor for not processing or rejecting the applications.

Responses:

1.1 During 2009 and 2010 DAScom submitted a total of 435 applications for wireless attachments to the poles of THESL. During that period, DAScom also submitted a total of 222 applications for wireless attachments to the streetlight poles of THESI which, at the time, were non-distribution assets. At least some portion of the THESI streetlight poles that were the subject of these applications have since been classified as distribution assets and will be transferred to THESL. Moreover, during 2009 and 2010, CANDAS understands that Cogeco submitted a total of 303 applications for attachments of fibre optic cabling to THESL poles in connection with the project to build the proposed Toronto DAS Network. No applications were submitted to any other Ontario electricity distributor in connection with any DAS network of which CANDAS has knowledge.

1.2 Of the foregoing applications, THESL processed a total of 184 DAScom applications and, as reported to ExteNet, a total of 186 Cogeco applications. THESI processed a total of 222 DAScom applications.

The last DAScom node attachment application was submitted to THESL in October, 2010.

1.3 THESL granted a total of 184 permits to DAScom for wireless node installations. THESI granted a total of 222 permits to DAScom for wireless node installations.

This is **EXHIBIT "I"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)

Questions:

2. *Reference: p. 9, para. 3.11*

CANDAS states "That the parties' settlement on this issue was reached after "considerable discussion" and resulted in universal access by all Canadian carriers (with only the Bell Canada carve out) is significant. As appears from the THESL Letter, THESL now takes the position that the CCTA Order does not apply to wireless attachments because there was no discussion about such attachments during the CCTA Proceeding and the Board never "turned its mind" to this issue. To suggest that wireless attachments are not within the scope of the CCTA Order because the issue was not debated in the CCTA Proceeding ignores the fact that the parties in that proceeding had already agreed, as part of the settlement, that access should be given to all Canadian carriers and not just to wireline carriers. Accordingly, there was no need for further discussion of this issue during the CCTA Proceeding. Moreover, to now suggest that the Board never turned its mind to the issue is to suggest that the Board and Board counsel did not apprehend that the definition of "Canadian carrier" included wireless carriers. Such a suggestion would be quite remarkable."

(a) Are wireless attachments explicitly discussed anywhere in the CCTA Decision?

(b) In the CCTA Decision, the Board was focused specifically on attachments made within the 2ft communications space on distribution poles. Please confirm whether all of the proposed Toronto DAS Network distribution pole attachments fit strictly within the 2ft communications space. Alternatively, please identify those components associated with the Toronto DAS Network that require attachment to the utility pole outside of the 2ft communications space.

(c) In the CCTA Decision, the Board determined that 2.5 attachments per pole was reasonable in the context of its Decision. In respect of the Toronto DAS Network, could 2.5 wireless distribution pole attachments be made to each distribution pole within the 2ft communications space? Please provide the relevant particulars regarding the response.

(d) At paragraph 3.15, CANDAS notes that "The Board ultimately decided the pole charge issue in a way that did not distinguish among various types of attachments." Are there any notable differences between wireline and wireless attachments? Did the Board explore these differences in the CCTA Decision? If so, please provide the relevant particulars, including specific references to the CCTA Decision.

Responses:

(a) See response to CCC 1.

(b) CANDAS does not understand the communications space on a pole to invariably be 2 feet. Rather, the communications space is the standard clearance between the power and neutral zones above, and the required clearance above grade for cable spans below. Components of the Toronto DAS Network that attach outside (below) the allocated communications space on node site poles include remote radio units, power supplies and related elements such as cables, connectors and switches, as described in the Written Evidence of Tormod Larsen (Exhibit D, sheets 3 and 4 of 4).

(c) In the CCTA Order, the Board adopted an assumption regarding the number of attachers, not the number of separate attachments, in respect of its determination of rates. CANDAS does not understand the Board to have made a determination regarding a reasonable number of attachments to a node site pole or the location thereof.

Depending on the nature and arrangement of the components attached to the pole and the size of the communications space on the pole, CANDAS believes that more than 2.5 attachments can appropriately be affixed to the communications space.

CANDAS has never suggested that a particular number of wireless attachments should be made "to each distribution pole" and, in fact, has noted that the numbers of poles to which wireless equipment may be attached are small in relation to the total number of distribution poles.

Wireline and wireless attachments include components that are not designed to, and do not need to fit within the communication space.

(d) CANDAS does not believe there are any differences between wireline and wireless attachments that are of significance for purposes of this proceeding.

Question:

38. *Reference: Ex. C, Second last slide entitled "Toronto DAS –Sidearm Installations"*

(a) Does this installation fit entirely within the 2ft communications space on the distribution pole?

Response:

(a) CANDAS believes that the point at which the side arm supporting the antenna attaches to the pole in the pictured installation fits within the applicable communications space. It occupies less than the 6 inches allowed between wireline cable attachments. Obviously, because the antenna itself is mounted on a stand-off support and projects away from the pole, the antenna and the side arm do not occupy any of the space in the communications space that is required for clearance between wirelines. The node equipment and power unit are shown affixed to the pole in an area below the communications space. The electric utilities often refer to this space as the unusable space (clearly a misnomer) because it is unusable for running power conductors or other wireline attachments, but it can be and often is used for wireless and other equipment installations.. This area of the pole below the communications space is also sometimes referred to as the common area of the pole. Cable TV companies use it to host power supplies and equipment enclosures. Wireline telecommunications companies also use this common space to install splice cases and equipment and some municipalities and public works departments use it to install traffic signal and surveillance equipment.

Questions:

45. *Reference: p. 4, Q. 7*

Mr. Boron states that: "all available capacity must be distributed equitably, in a non-discriminatory and transparent fashion - to all classes of users. THESL cannot decide to grant access to wireline attachers and cable companies, but not wireless attachers, on the basis of professed but unsubstantiated capacity issues."

(a) Does CANDAS propose:

(i) that "all available capacity" consists of the entire communications space?

(ii) that "all available capacity" consists of the unoccupied communications space?

(b) How does Mr. Boron/CANDAS propose applying this principle to the situation where multiple, competing suppliers for a DAS Network may exist within the City of Toronto?

(c) If all communications space on a pole is currently occupied, does CANDAS propose that that space be reallocated among more users (now including DAS attachers) with the result that one or more current occupants are displaced from the pole?

(d) What method does CANDAS propose for the rationing of available pole communications space among "all classes of users"?

(e) Please provide examples of permit applications that were denied for "professed but unsubstantiated capacity issues".

Responses:

(a) In the context of this question CANDAS does not propose that "all available capacity" is limited to the communications space, whether, (i) in its entirety or (ii) the unoccupied portion thereof. While the communication space that is available for the safe attachment of wireline cables is clearly the most significant portion of a pole and generally limited by external factors in such a way that space in this portion of the pole may be more readily subject to exhaustion, it is clear that for items of equipment related to both wireless and wireline services, other areas of a pole may be the most appropriate places for attachment. Additionally, even though the communications space is limited its dimensions may be different depending on the characteristics of each pole (CANDAS does

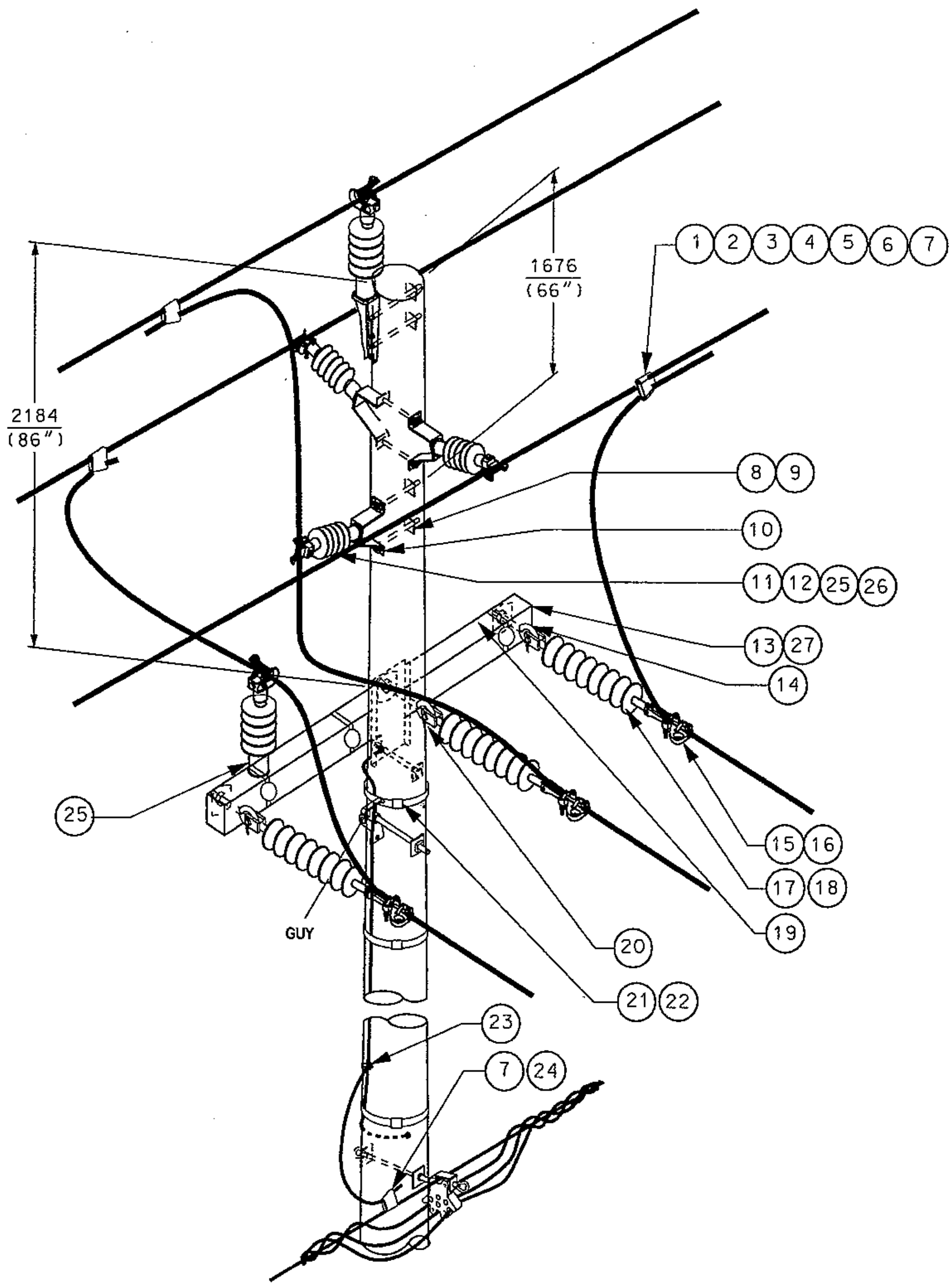
This is **EXHIBIT "J"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

Amanda Klein

A Commissioner, etc. (Province of Ontario)



1676
(66")
2184
(86")
1 2 3 4 5 6 7
8 9
10
11 12 25 26
13 27
14
15 16
17 18
19
20
21 22
23
7 24
25
GUY

This is **EXHIBIT "K"** referred to in the Affidavit of

MARY BYRNE

Sworn before me this 1st day of September, 2011

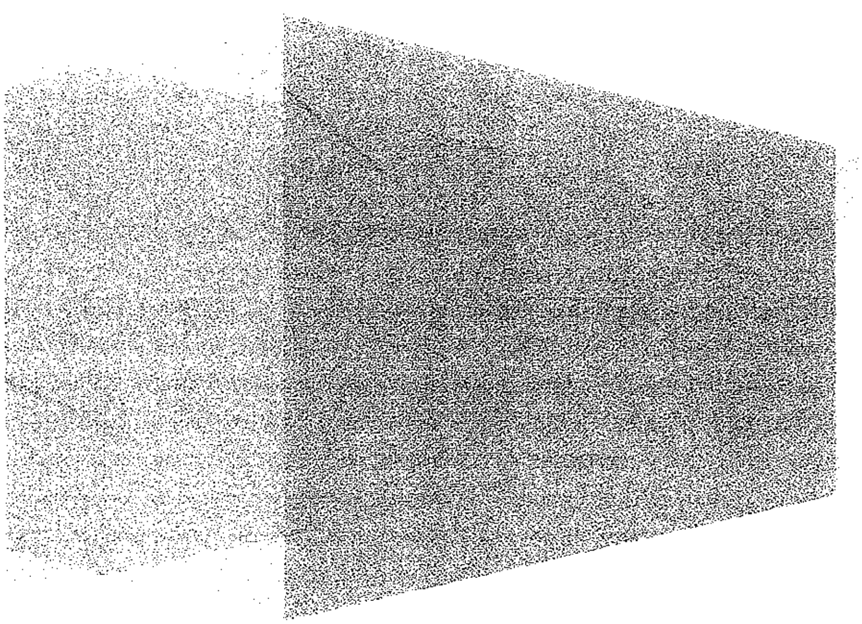
Amanda Klein

A Commissioner, etc. (Province of Ontario)

Electrical Distribution Capital Plan (EDCP)
2012 – 2021

Toronto Hydro-Electric System Limited

Version 1.42
August 9, 2011



(this page is intentionally left blank)

Table of Contents

Table of Contents (Cont'd)

Table of Contents (Cont'd)

Executive Summary

The electrical distribution system owned and operated by THESL is comprised of several components, including an overhead distribution system, underground distribution system, secondary network system and stations; each of which possess different features and characteristics that impact system performance and reliability in different ways.

When examining the system as a whole, it is clear that system reliability is gradually worsening over time due to the large quantity of aging and deteriorating infrastructure, and legacy and obsolete assets. There are a number of issues concerning the electrical distribution system as a whole, including lack of operational flexibility, lack of available capacity to meet future load growth, security of supply, and potential safety risks. The "worst performing" feeders on the system continue to experience an unacceptably high number of sustained outages within a 12-month time period. While there have been some successes with respect to underground system reliability due to the ongoing replacement of direct buried cable infrastructure, underground system reliability has not significantly improved over the past ten years. Overall, system reliability is up to three times worse when compared to the average of other world-class cities.

THESL also faces other challenges, such as cresting retirements, externally-driven plant relocation pressures, and day-to-day challenges associated with connecting new customers and restoring customers following outages. In order to improve system reliability over a ten-year period, two like-for-like intervention approaches were examined. One approach involved keeping the quantity of assets approaching end-of-life criteria at a constant level by replacing these assets with their standardized equivalent over a ten-year period. The second approach involved a balancing of system performance through the application of a risk-based optimization methodology in order to produce the optimal replacement schedule for each evaluated asset class. Execution of either approach results in high capital spending over the ten-year period with minimal improvement in system reliability.

To achieve reliability improvements, like-for-like replacement must be combined with a modernization effort. This effort is intended to address operational constraints and poorly performing legacy assets, mitigate potential safety risks, and install and enable new technologies across the system that will allow for better monitoring of assets and shorter outages to customers. The combined approach ultimately requires the same amount of capital spending as the either of the like-for-like intervention approaches, but produces significantly greater reliability benefits. The proposed ten-year capital investment plan, which reflects the combined approach, is expected to improve SAIFI (System Average Interruption Frequency Index) by 40% and SAIDI (System Average Interruption Duration Index) by 44%.

The Electrical Distribution Capital Plan ("EDCP") that follows presents the total capital investment program to be implemented over the next ten years (2012-2021). In addition to the aforementioned like-for-like replacement and modernization approaches, this plan also contains programs to mitigate the risks from critical issues associated with load growth and security of supply concerns, safety risks associated with non-standard equipment, externally-driven asset replacements and renewal, worst performing feeders and deteriorating stations infrastructure. This plan also manages the challenges associated with a retiring technical workforce, externally-driven plant relocation activities, connection of new customers to the system and the restoration of service to customers following outages.

Ultimately, execution of the EDCP ensures that THESL will make the optimal investment decisions to mitigate risks and improve system reliability, which will enable Toronto's electrical distribution system to achieve the reliability levels found in other world-class cities.

3.3 Overhead Distribution System

THESL's overhead distribution system consists of approximately 140,000 poles, 8,220 overhead switches, 30,720 overhead transformers, 4,100 circuit km of overhead primary and 10,900 circuit km of overhead secondary conductors.

Of the overhead assets evaluated within the Asset Condition Assessment program 50% fall within the Fair, Poor and Very Poor categories. It is expected that assets which fall into these condition categories will require replacement over the next ten-year period.

Key issues within the overhead distribution system include legacy rear lot and box construction, aging poles with reduced strength, legacy assets and accessories located near sources of contamination, bare and undersized conductor, improper fuse coordination, overloaded pole-top transformers, manual & remote-controlled gang-operated load break switches, overhead circuit design and overhead line crossings over highways. The remainder of this section focuses on the projects that will be executed to remedy these issues and mitigate potential risks.

Figure 24 illustrates the total capital spending required for the overhead distribution system. Several programs described within this chapter will be executed over the first five-year period, from 2012 to 2016. As a result, overall overhead system spending will begin to decrease in later years.

PORTFOLIO 2: OVERHEAD SYSTEM SUSTAINING PROGRAM: TOTAL COSTS ($ MILLIONS)										
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
O/H System	$93.0	$99.3	$112.2	$110.8	$109.9	$93.3	$83.9	$84.7	$86.3	$88.3

Figure 24 – Overhead System Total Costs ($ Millions)

3.3.1 Overhead System Feeder Automation & Fault Detection

As part of efforts to continually improve the distribution system with new technologies, THESL will be enhancing the overhead distribution system with the expansion of the Feeder Automation program and the installation of new fault indicators. This program will improve the operational flexibility of the system for the power system controllers, while also mitigating the risks associated with outages.

THESL has executed a total of ten Feeder Automation pilot projects over the past year on various portions of THESL's overhead distribution system. Each of these projects has demonstrated noticeable reliability improvements following an outage event. Given the success of these pilots THESL intends to expand this technology to the rest of the 27.6kV looped overhead distribution system. Benefits associated with the overhead system Feeder Automation program are similar to the planned underground system implementation, which are further described in Section 3.2.5. This program will permit the geographical expansion of Feeder Automation beyond the current pilot project feeders. With this expansion, the existing tie point switches connecting FA-enabled feeders to those feeders that currently do not possess this technology can be utilized in the future as part of the full Feeder Automation scheme.

On the overhead system, there are a number of obsolete motorized overhead gang-operated switches controlled via MOSCAD RTUs and a DARCOM radio system that the system operations control centre uses to communicate with these assets. As Feeder Automation is expanded into these areas, these assets will be replaced with new FA-compatible SCADAMATE gang-operated switches and RTUs.

While Feeder Automation is expected to greatly improve the operation and restoration of the feeder trunk circuits, this technology will not have any impact on fused lateral circuits, where a local outage will blow the fuse, and field crew workers will need to travel to the site to diagnose and repair the problem. To help guide field crews to the problematic areas, in-field fault indicators will be used to detect the approximate location of the fault.

Ultimately, this approach will reduce outage time, as the field crews can target the areas where assets need to be replaced. These fault indicators also provide valuable information with respect to momentary outages, which can significantly impact large commercial customers that employ sensitive manufacturing processes. This program will permit the installation of 36,000 new fault indicators throughout the overhead distribution system.

The deferral of this program will result in the continuation of prolonged outages and lack of operational flexibility. The currently installed Feeder Automation pilot project scheme will not be able to operate at its full potential, as many of the peripheral open point tie switches currently link these FA-enabled feeders to feeders that currently do not possess Feeder Automation technology. As such, the FA-enabled feeders will be unable to utilize these tie points to automatically transfer load.

3.3.2 Conversion of Overhead Egress Feeder Trunk Circuits

The egress feeder trunk circuit is defined as the circuit connection between the circuit breaker at the substation and the rest of the feeder trunk circuit. Entire loading on a given circuit will pass through the egress portion of the feeder trunk circuit. If this portion of this circuit fails, the entire feeder and all customers served from the feeder would experience a sustained outage. THESL classifies these as high risk assets.

There are certain feeders where the egress feeder circuit is on the overhead system. Overhead circuits are constantly exposed to non-asset-related risks, including weather-related, animal-related and human-related issues which can result in sustained outages. In some instances, these overhead egress lines connect to underground direct-buried XLPE cables within the station parameter. These portions of the feeder trunk circuit could be impacted by a wind or ice storm, resulting in a sustained outage to the entire feeder. The overall duration of this sustained outage would vary, depending on the available tie feeders and sectionalizing points along the impacted feeders.

The execution of this program will target key overhead egress assets on approximately 100 feeders and convert these to the underground system over the next ten-year period. The existing egress lines and portions of direct buried XLPE within these selected areas will be converted into tree-retardant XLPE in concrete-encased conduit (TR-XLPE).

3.3.3 Overhead System Operational Flexibility Improvement

Similar to the underground electrical distribution system, the overhead electrical distribution system exhibits a number of operational constraints which ultimately impact system reliability and operational safety. These include feeders with two or less distinct tie points to perform switching and load transfers and highly loaded and overloaded feeders that cannot take on any additional load under an outage scenario. The locations of these feeders are illustrated in Figure 20.

As noted in Section 3.2.7, 49 feeders within THESL's 27.6kV electrical distribution system have been identified with two or less available unique tie points, and 603 feeders on the 13.8kV & 27.6kV systems respectively possess utilization values of 25% to 75%.

This program will permit new unique tie points to be installed on feeders that have two or fewer unique tie points. As part of this activity, overhead circuits will be expanded to other nearby circuits in order to establish new tie points. Note that this program will be executed in alignment with the overhead system Feeder Automation program, as FA-enabled feeders must have sufficient feeder tie points and associated tie feeders in order to sufficiently take advantage of this automated system. As part of this exercise, overloaded feeders will also be addressed to ensure that appropriate tie points are created.

These programs will collectively assist in reducing outage durations on the overhead distribution system, as power system controllers will have more flexibility to execute load transfers when required.

3.3.4 Aging Poles with Reduced Strength

From the Asset Condition Assessment program, approximately 51% of wood poles within the overhead distribution system have been identified as possessing a condition grade of Very Poor, Poor or Fair. Most of the assessed wood poles have a condition score of Fair.

Depending on the installation of the pole asset, a number of degradation factors may reduce pole strength, including internal rot and decay at the groundline, shell rot and external infestation.

Poles with reduced strength present operational risks to THESL crew workers, potential safety risks to the public and reliability risks to the overhead distribution system. The combination of poles with reduced strength coupled with severe weather can lead to end-of-life failure scenarios where multiple poles lose their structural integrity and fall to the ground.

It is expected that over 54,500 poles with a condition grade of Very Poor, Poor or Fair will require replacement over the next ten-year period. These poles are further detailed in Figure 25. In addition to these poles, other items attached to the overhead infrastructure will also be replaced, including non-standard porcelain insulators. Should this work be further deferred, the number of poles in the Poor and Very Poor condition categories will grow and present further operational, safety and reliability-related risks. Under a run-to-failure scenario, approximately 13,035 pole end-of-life failures have been forecasted to occur over the next ten years.