EB-2017-0182
EB-2017-0194
EB-2017-0364

ONTARIO ENERGY BOARD

Upper Canada Transmission Inc. (on behalf of
NextBridge Infrastructure)
Application for leave to construct an electricity
transmission line between Thunder Bay and Wawa, Ontario

-and —

Hydro One Networks Inc.
Application to upgrade existing transmission station facilities
In the Districts of Thunder Bay and Algoma, Ontario

-and —

Hydro One Networks Inc.
Application for leave to construct an electricity transmission line
between Thunder Bay and Wawa, Ontario.

ARGUMENT-IN-CHIEF OF HYDRO ONE NETWORKS INC.

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I. Introduction and Overview

1. This is the argument-in-chief of Hydro One Networks Inc. ("HONI") in the following matters before the Ontario Energy Board ("OEB").

(i) EB-2017-0364, which is an application by HONI for leave to construct the Lake Superior Link ("LSL") a new 230 kV transmission line between Lakehead TS and Wawa TS in northwestern Ontario. This application will be referred to herein as the "HONI Application".

(ii) EB-2017-0194, which is HONI's application for leave to upgrade certain transmission facilities to connect to the East-West Tie ("EWT") line. This application will be referred to herein as the "Stations Application"; and

(iii) EB-2017-0182, which is an application by NextBridge ("NB") for leave to construct the EWT line between the same two points as the HONI Application. This will be referred to herein as the "NB Application".

2. The HONI Application and the NB Application will be referred to herein collectively as the Leave to Construct Applications ("LTC Applications"). The line for which both HONI and NB seek leave to construct will be referred to herein generically as the "EWT" or the "EWT line".

3. There is no dispute as to whether the Stations Application should be granted approval. Completing the upgrades on the stations is necessary for the EWT line, regardless of who builds that line. Without the stations work, the transmission line serves no purpose. There is no dispute that the Stations Application meets the criteria set out in section 96 of the *Ontario Energy Board Act, 1998* ("OEBA"). The Stations Application should, therefore, be approved.

4. The question to be resolved is which of the competing LTC Applications to build the EWT line should be approved. The difference between the two applications, and the reason why the HONI Application should be approved, is that the HONI Application satisfies the criteria under section 96 of the OEBA, while the NB Application does not. The evidence is clear that HONI has a lower cost alternative, resulting in a lower price impact to ratepayers. With

respect to quality and reliability of electricity service, again, HONI's proposal for the LSL is in all respects equal to, and in many respects superior to, NB's proposal for the EWT line. The granting of leave to construct to HONI will satisfy the interests of consumers with respect to price, and the reliability and quality of electricity service.

5. NB's claim to the superiority of its proposal, a claim which has in large measure driven all of the proceedings related to the three applications, and the NB motion attempting to dismiss the HONI Application, is that it can have the EWT line in service by 2020. But it is clear on the evidence that the EWT line cannot be in service in 2020 regardless of who builds the EWT line.

6. The evidence is clear that until the end of 2022, the capacity needs of the transmission system can be managed by the IESO, at a reasonable additional cost, from existing sources of supply. The additional cost, *if the need arises at all*, does not justify paying at least $100 million more to construct the EWT line and does not justify burdening ratepayers with ongoing annual higher OM&A of $2.4 million costs if NB constructs the line. Approving HONI's LSL application provides long-term benefits to Ontario's ratepayers in the form of lower revenue requirements (approximately $50 million[1] per year) for the life of the line, achieved not only from the lower capital costs of the HONI project but from additional tax savings from HONI's offering of a higher First Nations ("FN") equity ownership and from substantially lower ongoing OM&A costs. There is, as a result, no justification for approving the NB Application.

7. Consideration of the competing merits of the NB and HONI Applications has been clouded by considerations of Indigenous consultation and the process for obtaining the required environmental approvals, matters which should not be determinative of which of the LTC Applications should be granted. Both considerations are outside the OEB's jurisdiction under section 92 of the OEBA, as confirmed by the OEB at page 3 of Procedural Order No. 4 and Procedural Order No. 6 of this proceeding; and, in addition, the concerns can, in any event, be more than adequately addressed by HONI.

[1] Exhibit I, Tab 1, Schedule 17 based on Year 2, excluding cost updates are provided in Exhibit I, Tab 1, Schedule 11 and Exhibit 1.NextBridge.STAFF.54.

8. The issues to be considered in assessing these applications are determined by s. 96(2) of the OEBA, namely, price, reliability and quality of service. The fact that there are two LTC Applications should not alter the Board's test in assessing a leave to construct application.

9. This argument-in-chief will begin with a review of the Designation Process, including identifying the ways in which NB would have the Designation Process used in a manner that would distort consideration of the issues in the Leave to Construct Applications.

10. This argument-in-chief then deals with the following issues:

(i) Price Impact on Uniform Transmission Rates;

(ii) Reliability and Quality of Service;

(iii) Indigenous Issues; and

(iv) Environmental Assessment Issues.

11. In the hearing of its LTC Applications, NB has unfairly made a number of criticisms of aspects of HONI's proposal for the EWT line. The way in which those criticisms were made, and the criticisms themselves, compel HONI to address them herein.

II. The Designation Process

12. A fair consideration of the issues in the LTC Applications, and of the competing applications of HONI and NB, cannot take place in isolation from the Designation Process. The manner in which NB would have the OEB interpret the Designation Process would have the OEB distort the way it interprets its statutory mandate under sections 92 and 96 of the OEBA.

13. HONI submits that NB would have the OEB believe that the Designation Process has conferred rights and benefits on NB, to the detriment of any competitor. HONI submits that giving effect to NB's position would be incorrect, unfair and to the detriment of consumers and that, in making its decision on the competing LTC Applications, the OEB must ensure that such alleged rights and benefits are neutralized. The failure to do so, HONI submits, would violate the principles underlying the Designation Process and would be contrary to the public interest.

14. The Designation Process was created pursuant to the OEB's policy entitled "Framework for Transmission Project Development Plans" (EB-2010-0059). One of the stated objectives of the policy was to "support competition in transmission in Ontario to drive economic efficiency for the benefit of ratepayers"[2].

15. The then-Minister of Energy wrote to the OEB by letter dated March 29, 2011, stating that what would become the Designation Process would "also support competition in transmission in Ontario to drive economic efficiency for the benefit of ratepayers"[3]. (Emphasis added)

16. The OEB, in its Designation Decision, stated "Designation does not carry with it an exclusive right to build the line or an exclusive right to apply for leave to construct the line"[4].

17. The six parties seeking approval to undertake the development work, and to recover the costs of doing so from ratepayers, submitted forecast costs for both the development and construction phases of the project. Consideration of those costs thus took place in a competitive process, a process which disciplined the cost estimates. NB was successful in part because of its forecast construction costs. Had its forecast construction costs been approximately 80 percent higher than what NB forecast, as they turned out to be, it is unlikely that NB would have been chosen to undertake the development work.

18. As noted above, in its Designation Decision the OEB stated that the selection of the party to do the development work did not give that transmitter the right to build the line. NB however, has taken advantage of the Designation Process to the detriment of ratepayers. NB failed to advise the OEB and the public of the near certainty that its costs to construct the EWT line would be much higher than what it had forecast in the Designation phase, even when there were known facts that would increase its costs to construct the EWT Line, e.g., the change to the in-service date and the change in routing around Pukaskwa National Park ("the Park").

19. NB's submissions on development costs reads as follows:

[2] EB-2010-0059, "Board Policy: Framework for Transmission Project Development Plans", August 26, 2010, p.1.
[3] Letter from the Minister of Energy to the Chair of the Ontario Energy Board, March 29, 2011.
[4] EB-2011-0140, "East-West Tie Line Designation Phase 2 Decision and Order", August 7, 2013, p. 4.

> "NextBridge's evidence notes the distinction between the regulatory view of a development period that ends with the filing of a leave to construct application and the project management view of development and construction activities. From a project management point of view, regardless of the particular point in time at which a leave to construct application is filed, *effective and efficient management requires a continuous focus on the ultimate goal of completing the project on time (in this case, by the end of 2020) and within the development and construction period cost estimates/budgets.*[67] (Emphasis added) The evidence in this case explains in considerable detail how NextBridge applied effective and efficient management to the EWT Line Project throughout the Extended Development Period with a focus on completing the project on time and within the estimates and budgets for the project."[5]

20. After notifications from the OPA, now the IESO, on September 30, 2014, that the recommended in-service date of the project had been delayed from 2018 to 2020, and notification from the CEO of Parks Canada on June 1, 2015, that NB would not get access through the Park[6], NB doubled their development cost estimate on May 15, 2015. Interestingly, however, construction costs remained unchanged. Effective and efficient management would have, at a minimum, recalculated construction cost estimates. NB's evidence however, is that NB never updated its construction cost estimates until a few months before the NB LTC filing, more specifically April 2017[7]. That update is more than two years after being notified of the delay in the recommended in-service date. Not once, in over two years, did NB update the NB construction estimate.

21. NB, with reasonable enquiries, should have known, at the time it was advised that it would not get access through the Park, or at the time the IESO delayed the recommended in-service date from 2018 to 2020, that the cost of construction would certainly increase. Had NB advised the OEB of that, other transmitters could have considered, at a much earlier date, whether they would like to submit LTC applications and initiate development activities accordingly.

[5] EB-2017-0182 – NextBridge Argument-in-Chief on Development Costs – September 11, 2018 – Paragraph 40
[6] EB-2011-0140 – NextBridge Update Report – June 24, 2015
[7] Technical Conference Transcript – May 16, 2018 – p.62

22. NB responded to a question from Ms. Duff about how it would respond to a suggestion from HONI that NB had an unfair advantage, given that, as the designated transmitter, it had five years in which to build relationships, as follows:

> But they could have had conversations with these communities for the past five years. There is nothing precluding them from doing that. [8]

23. Such conversations might well have taken place had NB disclosed, by 2015, that its construction costs were almost certainly going to increase materially, in which case competing bids might have been viable.

24. Rather than advising the OEB of the virtual certainty that its construction costs would increase, NB made no effort to ascertain if the original construction costs that it forecast in the Designation phase were still valid. Failing to advise the OEB of the likely increase in its construction costs conferred a number of unfair advantages on NB. It gave NB time to develop relationships with Indigenous communities, relationships which in some cases were cemented by exclusivity agreements to prevent Indigenous communities from discussing equity participation or even economic accommodation with any competing transmitter. It gave NB an early start on the environmental assessment process, the work product of which NB incorrectly and unfairly insists is proprietary information[9] for its own benefit rather than the benefit of the project. It is this early start that NB relies heavily on in support of its LTC application.

25. NB's position, namely that it is entitled to leverage for its own benefit its role as Designated Development Transmitter for the project, should not be rewarded by the OEB. NB's position is anti-competitive and would thwart the purpose of the policy established by the OEB in EB-2010-0059.

26. The two unfair advantages identified paragraph 24 above provide the basis for which NB claims that its LTC Application is superior to that of HONI, namely that these two advantages enable NB to meet an in-service date of 2020, a date which the evidence in these proceedings has made clear is no longer necessary to meet. NB never defends its high forecast

[8] Transcript, Vol. 7, p. 69.
[9] NextBridge Additional Material – April 30, 2018 – Attachment A, p. 7 of 15

construction costs and instead relies principally on the support of Indigenous groups and the status of its environmental assessment work, both in comparison to HONI, as the core of its argument in support of its LTC Application.

27. To neutralize what HONI submits are NB's unfair advantages, HONI respectfully submits that the OEB should do the following:

(i) It can recognize the reality that the EWT line cannot be in-service by 2020, and so disregard those aspects of the NB Application that depend on achieving that in-service date;

(ii) It can allow the EA process to take its course, and not prejudge either the outcome of that process or the decision-making of the responsible Minister;

(iii) It can allow the Indigenous communities the opportunity to make satisfactory arrangements with HONI, as they have successfully done for other recent HONI projects around the Province; and

(iv) It can allow HONI to make satisfactory arrangements with affected landowners and other holders of land rights, something which, as the OEB well knows, HONI has been able to do successfully for decades in constructing many OEB-approved transmission lines.

28. HONI submits that in doing those things, the OEB can allow a fair consideration of which of the two competing LTC Applications satisfies the criteria in sections 92 and 96 of the OEBA.

29. As the OEB knows, HONI has extensive experience in building, operating, and maintaining transmission lines throughout Ontario, including northwestern Ontario. HONI knows the Province, knows the climate, and most importantly knows the customers it serves. As the OEB is aware, HONI is the principal high-voltage transmitter in Ontario, owning 98% percent of the transmission system across the province, transferring energy from generators to almost 14 million Ontarians across the province and directly serving 1.3 million distribution

customers. Operating over 30,000 kilometres of transmission lines across the province, including the existing EWT line, at a high degree of reliability, is one of the primary goals of HONI. Based on over 100 years of local presence and history, HONI has the confidence that it can build the line, operate the line and maintain the line, and that HONI will always be here. HONI has existing infrastructure and a huge dedicated fleet of equipment and personnel already situated in Northern Ontario and at the Grid Control Centre. HONI monitors the grid today and can immediately respond to any circumstance, emergency or not. Conversely, NB will be running a skeleton crew, relying on two employees working 24/7, with support from Texas and southeastern Ontario, and some external contractors with helicopters, as needed and as available[10].

30. HONI has had to design and operate transmission lines in accordance with approved environmental assessments, and in ways which minimize any impact on the environment, as well as meet any and all technical codes and standards established by regulatory bodies to maintain a high level of reliability and compliance.

31. HONI directly serves 88 First Nation communities and thousands of Métis across the province. HONI has a corporate Indigenous Relations Policy that embodies HONI's public commitment to working with Indigenous peoples in a spirit of cooperation and shared responsibility. HONI acknowledges that Indigenous peoples have unique historic and cultural relationships with their land and a unique knowledge of the natural environment. Forging meaningful relationships with Indigenous peoples based upon trust, confidence, and accountability is vital to achieving our corporate objectives. On this project and future projects, HONI will respect the rights of Indigenous peoples including the Aboriginal and treaty rights of Aboriginal peoples as recognized and affirmed in section 35 of the *Constitution Act, 1982*.

III. Price of Electricity Service

32. The OEB, in fulfilling its mandate under s. 96(2) of the OEBA, must look at the overall benefits to Ontario ratepayers in terms of the price of electricity service. The OEB must consider the advantages of the HONI Application over the cost of the NB Application. These price benefits to Ontario's ratepayers will be achieved in the following ways:

[10] Transcript, Vol. 6, p.57

(a) Greatly lower overall cost to construct the line;

(b) Significantly lower income tax to be included in future revenue requirements;

(c) Greatly lower ongoing OM&A costs; and

(d) Lower overall cost to be recovered from Uniform Transmission Rates.

(a) Cost to Construct the Line

33. The difference in the cost to construct the line is between HONI's forecast of $625 million[11] and NB's minimum cost of $737 million[12], a difference of $112 million.

34. Within the OEB's existing framework and practices, HONI has effectively provided a not-to-exceed price of $642 million inclusive of development costs. HONI's testimony is that any amount in excess of $642 million is at risk, and any recovery of that excess amount is subject to approval by the OEB according to two stringent tests. The first test is that any excess amount would need to have been prudently incurred to be reasonable. The second is that the excess amount would have had to be unforeseeable. As a result, these costs would have to be for items not currently captured in HONI's risk register. HONI has been transparent as to the accuracy of the elements within the overall construction cost, as well as how potential delays may impact both costs and schedule (i.e., EA approval delay beyond August 2019).[13]

35. HONI's total costs of $642 million are based on a ready-to-execute fixed-price and schedule-bound EPC contract with SNC-Lavalin that covers 85% of these costs, or $547 million. This mitigates any risk exposure to Ontario ratepayers. Conversely, NB also has a fixed EPC contract with Valard, however, the value of the contract makes up less than 60% of its construction costs[14], leaving a much greater portion of NB's price in the category of subject to increase. NB also notes in interrogatory responses[15] that the construction contract would not be subject to escalation adjustments, unless the project is delayed beyond the in service date of 2020. Despite never providing an updated EPC contract, NB revised this evidence during

[11] This represents only construction costs. Development costs are estimated at approximately $17M.
[12] Exhibit K4.2.
[13] Exhibit I, Tab 1, Schedule 7.
[14] Exhibit.I.B.NextBridge.HONI.8 – January 25, 2018
[15] *Ibid.*

testimony by stating that the EPC contract now takes into consideration escalation, including labour rates, through 2021.[16]

36. There are significant differences in the division of responsibilities of Owner and Contractor between the SNC-Lavalin and the Valard EPC contracts. There are more interface risks in the Valard contract that ultimately increase the risk of cost increases to customers. For example, the HONI contract gives accountability for both engineering and engineered material sourcing and construction to the contractor, SNC-Lavalin, whereas in the NB contract engineering and sourcing remains with NextEra and construction is with NB's contractor, Valard. In the NB agreement, if an issue arises, for example an engineering omission or an issue with procurement (delivery timing, quantity or quality) and the issue impacts construction cost or schedule, Valard will be eligible for recovery of additional costs through a change order. Conversely, because SNC-Lavalin has accountability for engineering, procurement and construction, the interface risks that may drive cost and schedule change are captured within the fixed-price contract, and customers are insulated from those cost increases

37. NB testified that, on the eve of the hearing of the LTC Applications, it had Valard change the construction schedule in an attempt to meet the 2020 in-service date, but did so without an increase in the cost of construction. That such a material change could be made with no cost consequences is not credible. A material change in the contractual relationship between Valard and NB, one that may have material consequences on the cost of construction, has been made without it being memorialized in any way[17]. As a result, no one can objectively examine the accuracy of NB's assertions.

38. Contrary to what the NB witnesses suggested, HONI is experienced in contract management and will, of course, have oversight of SNC-Lavalin's performance on the project from multiple dimensions including, but not limited to cost, schedule, quality, safety performance, and environmental compliance.

39. HONI and SNC-Lavalin have submitted evidence and provided testimony regarding the utilization of industry best practices in the determination of risk and contingency.

[16] Transcript, Vol. 7, p. 51, lines 10-15.
[17] Transcript, Vol. 6, p. 138.

HONI's project has a total of $60 million of risk and contingency within the $642 million estimate, which has been defined utilizing risk registers and Monte Carlo simulation to probabilistically determine what contingency should be funded. HONI has also provided evidence in the form of Monte Carlo simulation to demonstrate the confidence interval in being able to have the project completed by December 2021. Conversely, NB has not utilized a probabilistic-based approach and instead is asking the Board to rely solely on NB's judgment and experience, a "trust us" approach, which thus far based on their performance during the development phase, HONI submits, has not served customers well - an approach that could leave ratepayers with a substantially higher cost than anticipated if NB is approved to build the line.

40. HONI's project cost of $642 million has been clearly defined, and the estimate has a much tighter upper-bound when compared to the NB estimate. Through evidence and testimony, NB has attempted to blur together two distinct dimensions of a cost estimate: i) completeness of underlying milestones and deliverables; and ii) price tolerance. Regarding i), HONI will be at a Class 2 estimate, based on project definition milestones, by end of 2018. It is true that NB has completed more of the underlying project definition milestones within the AACE framework, which currently puts NB already within a Class 2 project definition. However, the important distinction to keep in mind is that NB has been working on this Project since 2013 and has spent approximately $80 million to achieve a Class 2 project definition. This extra time and money spent has not translated into any price or schedule certainty for Ontario customers. Regarding ii), as continually communicated during the oral hearing, NB's cost estimate has a 10% upper-bound, which NB refers to as its "management reserve." HONI's baseline cost estimate has a 6% upper-bound and substantially reduces risk of cost increases to customers as documented in response to Technical Conference Undertakings on May 25, 2018, specifically, Exhibit JT 2.25. It is not the 30% amount that NB has been falsely asserting.

41. NB has labelled 10%, or $73.7 million, as a management reserve, which means that as per project management practices, NB is considering that amount to be part of its project budget and therefore a potentially funded liability.

42. NB's forecast cost is unreliable. In Exhibit I.NextBridge.SEC.24, submitted on September 24, 2018, and in testimony[18], NB states that project costs are in 2020 dollars. When explicitly asked if the NB forecast cost was in 2020 dollars in January, NB responded "No. The total project cost in Table 1 is stated in nominal dollars, which is sometimes referred to as outturn dollars."[19]. It is unclear if NB's $737M cost to construct represents the costs as of 2017 or what they will be when the line is placed in-service – if the cost is in 2017 dollars, the $737M are understated and will need to be inflated.

43. NB asserts that the OEB should have confidence in its construction costs because they are the result of a competitive process. Its argument is simply that the forecast cost of $737 million was derived as result of a competitive process, albeit a limited one. Having received construction bids so far in excess of the NB forecast construction costs in the Designation phase, NB could, and should, have sought further bids or made efforts to reduce these costs. NB has been unapologetic about the massive increase in its forecast construction costs.

44. Over the course of the proceeding, NB has repeatedly said that the cost of construction would increase as a result of any delays in the schedule of construction. That is reflected in the following:

(a) In January of 2018, NB responded to an interrogatory from the Consumers Council of Canada by stating that "without knowing the duration of the delay beyond the fourth quarter of 2018, it is not possible to determine the impact of any delay in project costs"[20].

(b) In the technical conference held on May 16, 2018, Mr. Mayers, on behalf of NB, stated, "You may expect costs to increase, depending on how long the delay is." He further stated that if the delay were a year, the contingency in the forecast amount "probably couldn't cover that". He further stated that there could be some price escalation in its construction contract, "depending on, again, the timing"[21].

[18] Transcript, Vol. 5, pp. 13-14.
[19] Exhibit I.B.NextBridge.HONI.7a – January 25, 2018.
[20] Exhibit I.B. NextBridge CCC 1.
[21] Technical Conference Transcripts, May 16, 2018, page 144.

Mr. Mayers then gave an undertaking to provide an estimate of costs that NB would incur as a result of a delay of six months or one year to the in-service date.

(c) The undertaking response, which is Undertaking JT1.25, states that "NextBridge expects delay costs associated with a delay of six months or even a year would be substantial". Undertaking JT1.25 further states that "a six-month delay in the EA approval or subsequent MNRF permits that cause NextBridge to completely lose the 2018/2019 winter construction season will have a significantly greater cost impact as certain areas forecasted for this winter construction period will be delayed a year due to seasonal restrictions."[22]

45. In response to OEB Staff Interrogatory 49, a response delivered on September 24, 2018, NB stated that any increase in the cost of construction would be a function of a number of factors, including the following:

> - increasing equipment and crews and/or shifts to achieve a December 2020 in-service date or as close to 2020 as possible based on receiving a decision on its Leave to Construct;
>
> - adjustment to equipment, materials, and labour as may be impacted by the schedule consistent with Article IV of the EPC agreement;
>
> - increased oversight of additional construction crew and/or shifts.[23]

46. In response to HONI interrogatory 12, NB stated, "The incremental cost of construction would be a function of (1) additional environmental conditions that would need to be in place to start construction in the Summer of 2019 versus the Fall of 2018 as original [sic] planned"[24]. The significance of that statement is that it acknowledges that changes in the construction schedule give rise to increases in construction costs. That statement was made on September 24, 2018; but not quite three weeks later, NB testified that it had changed its construction schedule but that doing so would incur no additional costs.

[22] Undertaking JT1.25.
[23] Interrogatory Response, Staff 49
[24] Interrogatory Response, HONI 12

47. In the same interrogatory response, NB stated that "the terms and conditions of the Valard contract have not changed since the date it was filed in NextBridge's response to Staff Interrogatory #7 at Exhibit I.B.NextBridge.STAFF.7, Attachment 3 (Redacted)"[25]. That statement was made on September 24, 2018; but not quite three weeks later, NB testified that the construction schedule, which is included as an exhibit to the Valard contract, had been changed in a material way to shorten the construction period and to change the sequence of construction.

48. Despite not having a confirmed construction schedule start date, NB did assert that its construction costs will remain within the AACE Class 2 construction cost estimate which allows for a 10 per cent increase in the forecast cost of construction. The effect of that increase would be to increase the forecast cost by some $73 million, to $810 million[26].

49. Thus, until the third week of September, 2018, NB was asserting that delays in the in-service date of 2020 would increase its construction costs, perhaps by as much as 10%. However, by the time of the hearing, NB was asserting that it could collapse its construction schedule with no increases in cost and that only for unknown unknowns would the *management reserve* of 10% take effect. In its testimony, NB tried to assure the OEB that its constructor, Valard, had agreed to maintain the cost of $737 million, while materially shortening the construction period. NB did not produce the new construction schedule so that the OEB or intervenors could independently assess the accuracy of the new claim that the construction schedule could be shortened without increasing costs. NB also did not produce a witness from Valard so that the OEB or intervenors could independently assess the truth of the assertions that NB was making. NB provided no written communication, either from Valard to NB or internally within NB, that the change in schedule would have no effect on costs. No one on the NB witness panel had heard Valard assert it could change its construction schedule without additional cost.[27]

50. Mr. Murray had the following exchanges with the NB panel on the subject of the changes in the schedule and increases in Valard's costs:

[25] *Ibid*.
[26] $737 million plus 10 per cent management reserve
[27] Transcript, Vol. 7, pp. 9-10.

> MR. MAYERS: Have they specifically told us? They agree that we will do milestone changes if there is an approval for us to go forward on this leave to construct. We have not talked dollars.
>
> MR. MURRAY: So you haven't talked dollars.
>
> MR. MAYERS: No.
>
> MR. MURRAY: But have they said to you nothing else in the contract has to change?
>
> MR. MAYERS: Not to my knowledge.
>
> MR. MURRAY: And has Valard ever told you that it does not anticipate there to be any changes or increases in the contract price as a result of the change from the fall of 2018 to the spring of 2019?
>
> MR. MAYERS: Not to my knowledge.
>
> …
>
> MR. MURRAY: Well, has Valard ever said, or has there been a discussion where Valard has said we agree there won't be any increases in costs as a result of this relocation from the fall to the spring?
>
> MR. MAYERS: No.
>
> MR. MURRAY: Has that question ever been asked?
>
> MR. MAYERS: I am not privy to all of the conversations that have been held with Valard, but not to my knowledge, no.
>
> MR. MURRAY: Is there anyone else on the panel who has had a conversation with Valard on this topic?
>
> MS. TIDMARSH: No.[28]

51. NB is, in effect, asking the OEB to once again "trust it" when NB asserts that, contrary to all of its other assertions throughout 2018, delays in the commencement of construction and changes in the schedule of construction will not result in an increase in cost, just as NB had asked the OEB to rely on its forecast of construction costs in the Designation

[28] Transcript, Vol. 7, pp. 9-10.

phase. HONI submits that that is simply not credible. The result is that HONI submits that the OEB can have no confidence in NB's assertion that it can construct the line for $737 million.

52. When members of the hearing panel pressed NB witnesses on the question of likely cost increases, NB's response was that it was confident that any increases would be within the 10 per cent range[29]. The conclusion of those repeated assurances is that the real forecast of NB's construction costs, the forecast the OEB should use to assess NB's LTC Application, is the $810 million figure[30].

53. NB places heavy reliance on its claim that its project can be classified as an AACE Class 2 project. HONI submits that reliance on the outer boundaries of the AACE classification system is not helpful. The OEB needs to assess NB's construction costs according to the actual circumstances, i.e., the actual circumstances of the compressed schedule and the related cost increases.

54. On the evidence, HONI's cost estimate for construction is not only materially lower than that of NB, but far more reliable.

(b) Lower Income Tax

55. HONI plans to offer a 34% equity partnership to the BLP First Nations. This will result in the creation of a new transmission company and/or partnership, similar to the new company that NB would seek to establish if it is selected to construct the EWT line. Because of the FN tax status, 34% of the return on equity earnings would be tax-exempt under the HONI proposal. This compares to the 20% FN ownership under the NB proposal, which would mean that only 20% of the return on equity earnings would be tax-exempt. As income tax forms a part of the annual revenue requirement that either transmitter would seek to recover from ratepayers, HONI's proposal provides additional ongoing annual benefits for ratepayers. As an aside, this 70% increased FN ownership, 34% FN ownership vs. 20% FN ownership, will provide additional community benefits through higher dividend payments.

[29] Transcript, Vol. 7, p. 25.
[30] $737 million plus 10 per cent management reserve.

(c) Lower Ongoing OM&A Costs

56. HONI has provided evidence that its ongoing incremental OM&A costs to manage the new LSL line will be $1.5M/year, contrasted with NB's updated forecast of $3.9M/year[31]. A substantial portion of NB's forecast OM&A costs arise from agreements with service providers. NB has no agreements in place to validate its estimate[32]. NB has provided no documentation to substantiate what the costs will be to maintain and operate the line, which will be a recurring cost to ratepayers over the life of the asset. NextBridge's estimate is predicated on a business model that will operate and maintain a 450km transmission line with two staff working 24/7. The approach is unrealistic and continues to be a moving target for NB. NB originally provided an OM&A estimate $7.4 million[33], then $4.7 million[34], and has now updated their OM&A estimate yet again to $3.9 million[35] due to "further efficiencies". How these estimates are being generated with no agreements in place is concerning.

57. HONI submits that though not necessarily in the purview of this panel for assessing the construction costs of these Leave to Construct Applications, recognition of the fact that there will be unnecessary redundant and potentially excessive costs for ratepayers in the future as a result of this leave to construct decision is something this panel should take into consideration. There is no basis or reason for having ratepayers incur an additional ongoing $2.4 million in annual OM&A costs.

(d) Lower Overall Uniform Transmission Rates

58. HONI is already an Ontario transmitter whose revenue requirement is recovered through Ontario Uniform Transmission Rates ("UTRs"). Much of the costs that constitute the revenue requirement are fixed in nature, e.g., equipment, facilities, fleet including helicopters. These items are situated throughout the province, including northwestern Ontario, and more specifically already serving the existing EWT line. Some of these fixed sunk costs which Ontario ratepayers are currently paying will not increase the necessary revenue requirement for

[31] Exhibit I.NextBridge.STAFF.54
[32] Transcript, Vol. 6, p. 57.
[33] Exhibit B, Tab 12, Schedule 1, Attachment 1- July 31, 2017
[34] Exhibit I.B.NextBridge.STAFF.30 – January 25, 2018
[35] Exhibit I.NextBridge.STAFF.54 – September 24, 2018

Ontario ratepayers but will rather be a reallocation of costs between HONI and the future HONI/FN partnership that will own the LSL line.

IV. Reliability

59. The OEB, in fulfilling its mandates under s. 96(2) of the OEBA, must also ensure that the new line is in the interest of Ontario electricity consumers with respect to the quality and reliability of electricity service.

60. In the context of the LTC applications, reliability has two components. One related to technical matters such as the design and structure of the line. The other relates to the date when the line will be in-service.

61. HONI's proposed LSL is a reliable and technically sound one, complying with all applicable regulatory standards. In response to an interrogatory from NB, asking whether HONI's installation of a four-circuit line in the Park would adversely affect reliability, the IESO responded as follows:

> HONI's proposed four-circuit line in the Park complies with NERC, NPCC and ORTAC planning standards and as long as Hydro One meets the conditions set out in the System Impact Assessment, Hydro One's proposed Lake Superior Link Project will not have an adverse impact to reliability.[36]

62. During the hearing, the IESO witnesses were asked a question based on the response to that interrogatory. The exchange was as follows:

> MR. MURRAY: Now, just stopping there, given that both Hydro One and NextBridge received a completed system impact assessment or SIA from IESO, is it fair to say that IESO does not have any concerns with the reliability for either proposal, to the extent that the system impact conditions are actually adhered to?
>
> MR. MARIA: Yes.[37]

63. Operationally, the project benefits of the HONI project do not end after the construction phase. HONI's century-long, Ontario-specific experience ensures the safe and

[36] IESO Response to NextBridge 22, September 24, 2018.
[37] Transcript, Vol. 4, p. 110.

reliable operation of the line. HONI's ability to respond to unpredictable events, for example the 2003 blackout, the Toronto flood, the ice storm events, and more recently the Ottawa tornado, is well known and, in the unlikely event of failure, HONI has extensive knowledge and experience in outage restoration. HONI has nearby response center teams in Thunder Bay and Sault Ste. Marie. HONI has a fleet of helicopters in Thunder Bay as well as in other locations in the North. In addition, HONI has over 250 trades staff readily available in the North. Together, these all provide HONI with a unique capability for timely restoration across the whole 400 km of the new EWT line from Wawa to Thunder Bay**.**

64. HONI submits that the relocation of T1M, which is included in the HONI construction price of $624 million, is a more reliable construction method than the proposal being brought forward by NB. By NB's own admission, the relocation of T1M will eliminate any potential reliability risk associated with the crossings, while the NB proposal would only mitigate the risk based on a workaround. This is confirmed in NB's response to a Staff interrogatory:

> Although avoidance of crossings by the relocation of these existing lines can be argued as an improvement of the reliability as it omits the risk of the new line being able to impact the existing lines, it is equally argued that the electrical transmission industry accepts crossing of transmission lines in such a manner to minimize the risk as a broadly acceptable mitigation for these reliability concerns. [38]

65. NB's case for the superiority of its LTC Application rests largely on the claim that it can build the line to be in-service by 2020. NB repeats, mantra-like, that it has been directed by someone to bring the line in-service by 2020. It continues to misrepresent the effects of the Order-in-Council[39] even in the face of the OEB's decision, on NB's motion, that the Order-in-Council did not order that the EWT line be in-service by 2020.[40] NB also insists on the 2020 in-service date on the face of evidence that the EWT line cannot be in-service by 2020 as a result of decisions taken by the Ministry of Energy, Conservation, and Parks ("MECP").

[38] Exhibit I.C.NextBridge.STAFF.12e – January 25, 2018
[39] March 4, 2016
[40] July 19, 2018

66. The IESO has provided a **recommended** in-service date. The IESO has never said this date must be met at all cost, nor has the IESO stated that the lights will go out if this Project is not delivered by December 2020.

67. Thus, there is a cost-benefit analysis that must be taken into account when considering incurring additional costs to meet a 2020 in-service date, in contrast to delivering the project for a cost and date beyond 2020. The IESO has completed this analysis and provided the documentation in this proceeding[41].

68. The IESO forecast is that any increase in the demand for electricity service in the northwest can be managed throughout 2021 and 2022, with the risk of some additional costs.[42] It should be pointed out that the IESO has been consistently adjusting the forecasts of increases in demand in the Northwest and the consequent need for the EWT line. It originally forecast the need for the EWT to be in service by 2018. It is clear on the evidence that any need has been managed satisfactorily, without material increases in cost, at least through 2019 and perhaps into 2020. That uncertainty and lower trend of growth relative to the historic IESO forecast in Northwestern Ontario casts doubt on the IESO's forecasts for 2021 and 2022. But even if those forecasts are accepted, the possible additional annual expenses in those years are low, relative to the savings achieved by building the EWT for over $100 million less that NB's forecast.

69. The IESO has projected the cost of incremental capacity requirements as a range between $7 million and $20 million in 2020 and $8 million and $28 million in 2021. HONI does not gainsay the importance of increased costs. It merely states the IESO has been consistently overly conservative in its forecasts to date, that there may in fact be no incremental costs in those years, and that any potential incremental system costs must be weighed against the definitive additional cost of allowing NB to build the EWT line.

70. NB's insistence on a 2020 in-service date was artificial to begin with and is now unrealistic given that the line cannot be in service until at least 2021. HONI submits that the OEB should not grant the Leave to Construct application on the basis of an in-service date which is effectively meaningless.

[41] IESO Updated Impact Analysis – June 29, 2018
[42] *Ibid.*

71. The following exchange, between Ms. Duff and the NB witness is telling:

> MS. DUFF: Scenario 1; the stations aren't ready until December 2021, and I understand all of the caveats about that. Do we have any information in evidence today of what that does to your cost, that therefore the Board says you know what, NextBridge, I know you are ready to go for 2020 but we really don't need it for 2021.
>
> If that is the scenario that's what the Board decides in this combined proceeding, do we have any information of what that does to your costs?
>
> MS. TIDMARSH: I will just confer with my panel. Thank you.
>
> [Witness panel confers.]
>
> MS. TIDMARSH: So if NextBridge did not have to accelerate to ensure that it was going to meet a December 2020 date, and a decision was made and communicated to NextBridge by the Board that the 2021 date was more appropriate, we believe that we could actually bring the costs in lower than what we have.
>
> So we have some costs in there that are -- you can see in IR 49 there's four caveats about doubling up on management crews and that type of thing.
>
> So we think that we will still be within the plus or minus 10 percent band, but we could be tighter on that.[43]

72. What that exchange reveals is that NB says that it could build the EWT line for less if it had to meet a 2021 in-service date. How much less is not known. The OEB is left not just with uncertainty about the NB costs to meet a 2020 in-service date but also with evidence that those costs are higher than what is required to meet the actual circumstances of when the EWT will be in-service.

V. Indigenous Communities

73. HONI has made significant progress with regards to Indigenous consultation on its proposed LSL Project. HONI has met with all 18 of the Indigenous communities identified by the Crown via the Ministry of Energy and is engaged in ongoing discussions with all of them. In addition to the list provided by the Crown, four additional Indigenous communities have

[43] Transcript, Vol. 7, pp. 49-50.

expressed an interest in the project, and HONI has engaged with them. HONI has signed Capacity Funding Agreements with several communities and is currently negotiating agreements with the remaining communities.

74. Consultation with Indigenous communities has been focused on sharing project-related information, meeting to discuss the project and understand community concerns, formalizing capacity funding agreements, and commenting on the Terms of Reference for the environmental assessment. In addition, several of the Indigenous communities are actively participating in the archaeology work. HONI's detailed consultation log, Exhibit I, Tab 1 Schedule 15, Attachment 1, provides a complete record of Indigenous consultation.

75. HONI acknowledges that accommodation is a very important aspect of consultation. As HONI has indicated in evidence to date, HONI's approach to accommodation is a package of benefits including, but not limited to, capacity funding, contracting and employment opportunities and a commercial partnership opportunity for the communities that make up Bamkushwada LP.

76. All Indigenous communities have been offered capacity funding agreements in relation to this project, including capacity for, among other things, the opportunity to hire a consultation coordinator from their community, participate in EA related reviews, traditional knowledge studies and host community meetings. The purpose of these capacity funding agreements is to provide Indigenous communities with capacity to be meaningfully consulted on this Project.

77. With regards to employment and contracting, HONI and its construction partner SNC–Lavalin are committed to maximizing Indigenous employment and contracting opportunities on the project. Substantial economic participation opportunities in the forms of employment and Indigenous contracting are an important aspect of HONI's project, and HONI will be maximizing these opportunities for Indigenous communities and businesses. In addition, HONI, unlike NB, is in a unique position to provide lasting employment opportunities throughout its network across the province for skilled Indigenous workers, beyond the construction of this project.

78. HONI is aware that there has been some concern expressed about the alleged one-year delay in construction schedule and its effect on employment opportunities. As was pointed out in testimony of Mr. Spencer:

> We have spent a lot of time in this proceeding talking about the end of construction, and when one looks at the beginning of the construction periods and you overlay our evidence I have just provided, as well as the NextBridge response to interrogatory Staff number 49, one can see that there is in the order of three or maybe four month's difference between the construction start on the two applications before this Board for consideration…. This delay of a few months is in the context of the overall project, and the longer term lasting benefits that HONI is in a unique position to be able to provide through not just the construction phase of this project, but potentially ongoing employment of skilled and qualified workers from across Indigenous communities[44].

79. The OEB has historically taken the position that it has no jurisdiction to deal with Indigenous consultation issues.[45] HONI submits that that is the correct position, based on the wording of section 96 of the OEBA.

80. Even if the OEB were inclined to consider Indigenous consultations as a relevant consideration, the evidence is that HONI, which, to the OEB's knowledge, has a history of successful engagement with Indigenous communities in formal consultations and equity participation agreements, has already commenced consultation, and is willing to continue consulting and, where appropriate, accommodate. In the case of BLP, HONI has stated that it is prepared to offer 34% equity participation.[46] That HONI has been unable to discuss, let alone reach, economic participation agreements with BLP and MNO is only the result of exclusivity agreements prepared by NB and entered into with both BLP and the MNO.

81. Although several parties expressed dissatisfaction with HONI's suggestion that it could reach an equity participation agreement in a minimum of 45 days, Ms. Goulais of HONI

[44] Transcript, Vol. 3, pp. 35-36.
[45] See, for example, the OEB's decision in *HONI Networks Inc., Lambton-Longwood Leave to Construct*, EB-2012-0082, where the OEB stated that it had no jurisdiction to conduct Aboriginal consultations itself, nor to assess the adequacy of the Crown's consultation efforts in a section 92 application (except as they may arise within the limits of section 96(20) as section 96(2) of the OEBA places specific limitations on the extent of the OEB's power to review.
[46] May 7 Additional Evidence, Attachment 12.

explained in her testimony that 45 days is only a minimum period, that HONI is committed to reach an equity participation agreement, and that the discussions could continue long after the commencement of construction. She further stated that in HONI's Bruce-to-Milton project, an agreement on equity participation was reached with the First Nations well after the line went into service[47].

82. HONI submits that the OEB has little to choose between HONI and NB in terms of what the Indigenous communities have been offered. NB's sole argument is that the benefits it offers to Indigenous communities will flow faster. That, again, turns on the timing of the in-service date. If the EWT line cannot be in service until 2021, which is a fact, that purported advantage effectively disappears.

VI. The EA Process

83. NB relies heavily on the claim that its EA and permitting process is closer to approval that that of HONI. This issue is not relevant if the 2021 in-service date is the realistic one, which HONI submits is clearly the case.

84. The OEB must grapple with three issues of regulatory policy. The first is the fact that the Designation Process, unfortunately and unintentionally, gave NB an unfair advantage and made effective competition more difficult in that it allowed NB to begin its EA process far earlier than any competitive alternative. To allow NB to rely on that unfair advantage, in the face of much higher construction costs and a more negative environmental footprint, is contrary to the policy objectives of the designation process.

85. The second issue of regulatory policy is that the OEB is asked, in effect, to pre-judge and speculate on the outcome of HONI's EA process, including with respect to what the Minister might do when asked to make a decision whether to issue a declaration order. HONI submits that, absent definitive evidence that HONI cannot secure EA approval so as to achieve a 2021 in-service date, the OEB should not embark on this speculative process.

[47] Transcript, Vol. 3, p. 9

86. The third issue of regulatory policy is whether a party, which has been allowed to recover the cost of its EA development work from ratepayers, should be permitted to deny ratepayers access to, and the use of, that EA work.

87. HONI accepts the OEB's long-held position that it has no jurisdiction over environmental matters except to the extent that such matters affect the in-service date or otherwise relate to the public interest[48].

88. The only issue for the OEB with respect to the EA process is whether there is evidence that HONI cannot complete the EA process, either by way of declaration order or by completing the individual EA process, so as to permit an in-service date of 2021. HONI submits that there is no such evidence.

HONI Has Two Options for EA Approval

89. HONI is proceeding on two parallel tracks with respect to its EA approval. One track involves awaiting the issuance of the EA approval for the NB project and then submitting a request for a declaration order to the Minister.

90. The other track involves continuing with the individual EA for the LSL and utilizing available information and studies to fast-track the EA approval process.

91. The uncontradicted evidence is that, on either of these tracks, HONI will secure EA approval or a declaration order in time to make a 2021 in-service [49].

92. In the case of a declaration order, HONI would, as instructed by the MECP, file its application after EA approval is issued to NB, which is expected in February, 2019. HONI has estimated six months for receipt of a declaration order. According to evidence from MECP, that timeline was not considered unreasonable by MECP [50].

[48] See, for example, the OEB decisions in *Detour Gold Corp (Re),* 2011 LNONOEB 211 at para 19, and *Grand Renewable Wind LP (Re)* 2011 LNONOEB 325 at para 8.
[49] Exhibit 1-I-14, Attachment 1 of HONI's evidence.
[50] Transcript, Vol. 7, 118-119.

93. Declaration Orders are usually considered when the proposal is in the public interest; where potential environmental effects are likely to be minimal; and where environmental impacts are already being adequately addressed.

94. HONI has submitted evidence that the LSL is a strong candidate for consideration of a Declaration Order. Specifically, the LSL would save over $100 million in capital costs and an additional ongoing $2.4 million in operating costs. Furthermore, the LSL project route reduces the linear distance of the line proposed by NB by approximately 50 km and reduces the required corridor width by approximately 50%. No widening of the corridor would be required within the Park. The route through the Park is the very same reference route utilized by NB in the Designation Phase as it is less impactful to the environment[51].

95. In the case of the individual EA, Mr. Evers of MECP admitted in evidence that HONI's proposed scheduling took into account all of the regulated timelines[52].

96. On this basis, there is no evidence to suggest that HONI will not secure EA approval for its LSL through one of the two EA tracks.

HONI Can Utilize NB EA

97. There has been no evidence to support NB's position that HONI cannot utilize NB's EA work to obtain a declaration order or expedite its individual EA.

98. Ms. Cross of MECP referred in her evidence to Section 30 of the *Environmental Assessment Act* which requires MECP to keep a public record for the EA and indicated that the only information that would be considered confidential from the proponent would be information that the proponent had identified as confidential[53].

99. Mr. Evers of MECP noted that information marked as confidential would also be subject to freedom of information requests and a determination would be made, even if

[51] EB-2017-0364, HONI Networks Inc.'s Section 92 – Lake Superior Link Project - Additional Evidence, May 7, 2018, p. 8.
[52] Transcript, Vol. 7, p. 120.
[53] Transcript, Vol. 7, p. 107.

documentation was marked confidential, as to whether the document nevertheless would be released through that process[54]

100. When Mr. Evers was asked about confidential documents submitted in the NB EA, he indicated that was not aware of any documents marked as confidential[55].

101. There have been assertions from NextBridge that referencing studies or information from NB's EA would violate copyright laws or otherwise be prohibited. However, there is no evidence that substantiates this position, nor is this position consistent with conduct by NB itself, who has similarly referenced studies by others in its documentation[56].

102. Ms. Tidmarsh suggested, in her evidence, that certain information relating to the NB EA was confidential and protected by governmental agencies. However, there is no evidence that suggests that HONI would not be able to access such studies or information. It is common practice for proponents to be provided access, typically with training or under confidentiality agreements, to access information held by governmental agencies such as MNRF. Indeed, HONI does so on a regular basis.

103. In addition, HONI has included, in its costing, the undertaking of traditional knowledge studies by all of the 18 indigenous communities.

104. MECP testified that, as long as HONI is meeting the technical requirements of the *Environmental Assessment Act,* MECP would review the information submitted by HONI without regard to its origin. As stated by Mr. Evers of MECP: "Where they gather that information is -- as long as they're meeting the requirements of the Environmental Assessment Act and our technical requirements, that is what we're looking for. We are looking for the merits of the information that is contained in that documentation."[57]

105. Finally, as stated in evidence by MECP in response to questions from the Panel Chair, Ms. Long, the EA approval is "granted to the project, because we do have instances where there are companies that sell off, sell their project, and the environmental assessment goes with

[54] Transcript, Vol. 7, pp. 108-109.
[55] Transcript, Vol. 7, p. 134.
[56] Transcript, Vol. 6, p. pp. 123-125.
[57] Transcript, Vol. 7, p. 112.)

them", and then Ms. Cross: "So we speak to the undertaking that is set out in a document, that is the EA."[58]

106. For all of the foregoing reasons, there is no doubt that HONI will be able to and is entitled to rely on the underlying studies and development EA work completed by NB.

No Basis to Doubt Parks Canada Approval

107. During the hearing, NB raised the hypothetical scenario where Parks Canada would, a year from now, decide not to permit the line to go through the Park and the corresponding impact on scheduling and a 2021 in-service date.

108. There has been no evidence presented by NB to explain why this hypothetical scenario merits consideration by the OEB, other than NB's assertion that it was denied access through the Park and had to determine another route.

109. The evidence is clear that NB was denied access through the Park because it had no legal right to go through the Park. In addition, NB's project envisioned a larger corridor through the Park in areas not currently occupied by lines. HONI has neither of these two challenges. Indeed, HONI's work is permissible in accordance with its Licence Agreement and subject to its terms.[59]

110. Further, as explained by Ms. Croll of HONI in evidence, HONI has been engaged in discussions with Parks Canada for some considerable time and has received no indication from Parks Canada that a route through the Park is not a viable option.[60]

111. To the contrary, Parks Canada has indicated in its November 27, 2017, letter that it is "not opposed to the project in principle." Further, on August 29, 2018, Parks Canada confirmed that replacement towers installed away from the current towers is an option that can be considered for the project.[61]

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[58] Transcript, Vol. 7, pp. 156-157
[59] EB-2017-0364 - -Additional Evidence, May 7, 2018, Attachment 3 (Licence Agreement); Exhibit C, Tab 1, Schedule 2, Attachment 2 (Letter from Parks Canada dated November 27, 2017
[60] Transcript, Vol. 4, pp. 37-38)
[61] Exhibit C, Tab 1, Schedule 2, Attachment 2 - February 15, 2018 (Letter dated November 27, 2017) and Exhibit I-1-14, Attachment 4 pp. 275 (Correspondence dated August 29, 2018)

112. HONI has been meeting with Parks Canada regularly and will continue to meet regularly with Parks Canada. HONI routinely requests and receives feedback from Parks Canada regarding its LSL project. There is no reason to expect that Parks Canada would, after more than a year of consultation already underway, identify a critical obstacle that would preclude approval of the LSL project in a year from now at the time of expected approval.[62]

113. As a federal regulatory body with responsibility for the Park, Parks Canada has been carefully reviewing and considering matters, and it is unreasonable to hypothesize that it would suddenly adopt a completely different position with respect to matters that have been under discussion for some time.[63]

NB's Threat of EA Withdrawal

114. During the hearing, Ms. Tidmarsh of NB gave evidence that NB might choose to withdraw the EA submitted to MECP if not awarded leave to construct.[64]

115. Without understanding the motivation that would prompt NB to intentionally take such action to the detriment of the ratepayers who NB expects will fund NB's EA development work (and further construction work up until a decision is issued by the OEB on the leave to construct applications), it is HONI's position that NB does not have that option, particularly now that MECP has completed its review of the EA and has published the Notice of Completion.

116. First, NB was designated as the transmitter for the development phase of the project and is required to complete that phase to be eligible to recover the cost of that work. The development work is clearly intended for the benefit of the project, not just the proponent. It is HONI's submission that NB would not risk recovery of its development costs and reputational damage by arbitrarily withdrawing its EA and, indeed, on cross-examination, NB wisely conceded that further discussion internally would be required before proceeding in this manner.[65]

117. In addition, legislation and rules published by MECP govern when and under what circumstances an EA may be withdrawn. Section 6.2(3) of the *Environmental Assessment*

[62] Transcript, Vol. 4, pp. 38-39).
[63] *Ibid.*
[64] Transcript, Vol. 5, pp. 38-39
[65] Transcript, Vol. 6, pp. 130-131

Act provides that a proponent cannot withdraw its EA after the deadline for completion of MECP review except "upon such conditions as the Minister may by order impose". One of those conditions could be that the EA will continue to the approval stage and be made available to other proponents.

118. MECP has now published its review which will be under consideration for five weeks from October 12, 2018. Therefore, as confirmed by MECP in evidence, NB cannot unilaterally withdraw its EA.[66]

119. MECP also indicated that another proponent could step into the original proponent's position and "take over the EA" if the first proponent stopped responding to comments from MECP, again suggesting that, even if NB decided to abandon the EA process, HONI could avail itself of the current status of the NB EA.[67]

120. Ms. Tidmarsh of NB testified that NB would be at risk of litigation if HONI relied on NB's EA and there were issues found with the studies. There is no basis for such a concern, particularly since most of the underlying reports to the NB EA specifically state that users and readers rely on the reports at their own risk. Further, case law confirms that consultants are not liable to anyone other than their clients for the studies and reports that they prepare.

121. Despite HONI's view that NB cannot and would not withdraw its EA, even if that occurred, HONI would continue to have the benefit of NB's EA information which is publicly available. This view is supported by the agreement of MECP to provide HONI with other information from the NB EA, which is no longer publicly accessible but considered part of the public record[68].

122. Further, MECP has confirmed that a declaration order, based on NB's EA work, is possible notwithstanding the withdrawal or lack of approval of the NB EA.[69]

[66] Transcript, Vol. 7, pp. 113-114
[67] Transcript, Vol. 7, pp. 114-115
[68] MECP September 27, 2018 correspondence, submitted as JT 1.0
[69] Transcript, Vol. 7, pp. 115-116

Approval for Stations Work

123. MECP has taken the position that, because the Marathon TS is connected to the individual EA for the transmission line, MECP cannot move forward with Class EA permits and approvals before the individual EA is completed. On this basis, MECP initially asked HONI to refrain from submitting any permit and/or approval applications to MECP and MNRF[70]. .

124. As indicated by Ms. Cross of MECP in her testimony, MECP has since reconsidered this position and has now indicated they will allow HONI to submit relevant permit applications for review, with approval held until such time as other conditions are met.[71]

125. NB does not seem to be concerned, nor has it taken any action to address the potential delays caused by MECP's position on the station approvals. The lack of any action taken or concern exhibited on the part of NB in response to MECP's position suggests that NB is not concerned and has accepted delay to the in-service date.[72]

126. During the hearing, MECP was asked about issuing permits in connection with Marathon TS and suggested that, if the NB EA were approved but HONI received leave to construct, issuance of the permits would need to await approval of the individual EA for HONI (or, although unstated, a declaration order for HONI).

127. HONI submits that this position has not been subject to verification within MECP and is inconsistent with other evidence. MECP has already reconsidered direction on the permitting aspect as outlined above. Further, this position is inconsistent with the evidence that the leave to construct decision is not relevant to the EA process and that the EA process would proceed on the NB EA even if NB were not awarded leave to construct.

128. In evidence, Ms. Cross of MECP stated, in response to a question regarding the lack of relevance of leave to construct to EA approval, "Well, we recognize that there are

[70] Exhibit I, Tab 1, Schedule 14, Attachment 30, p. 3 of 3 - May 15, 2018 email from Antonia Testa
[71] Transcript, Vol. 7, p. 136
[72] Transcript, Vol. 7, pp. 106-110

approvals that will be required in order to implement the project, but we're not relying on those approvals to all be in place before the Minister makes a decision."[73]

129. Given that an EA is approved for a project, as set out above, it is HONI's position that the station work should proceed upon EA approval of the line, regardless of which proponent is awarded the leave to construct. The line has been designated as a priority project, and there is no doubt that the line must be constructed and that the work will proceed.

NB's Construction Schedule Will be Delayed

130. NB will likely, even if it secures EA approval in February, be delayed in its construction schedule for the following reasons.

131. NB requires numerous permits and approvals to proceed with construction. In evidence, the MECP, which is only one of the many regulators that will be issuing permits and approvals, indicated that the service standard for one type of approval required by NB is 12 months.[74]

132. NB is now altering its construction schedule to try to expedite the work by undertaking highly sensitive clearing activities at times of the year that present the greatest risk in terms of impacts on species. There is no evidence from NB as to the detailed construction plans that would allow such work to proceed, whether indigenous communities are aware of the revised construction schedule and whether the regulators would allow such activities to proceed in the face of these risks to the environment. Any one of these matters could cause significant delay to construction activity.

133. In evidence, Mr. Evers of MECP indicated, in addressing the detailed project plan, that there are sometimes restrictions in the EA in terms of when clearing of trees can be done and when other activities can occur. Mr. Evers indicated he did not know if such restrictions were part of the NB EA.[75]

[73] Transcript, Vol. 7, p. 145
[74] Transcript, Vol. 7, pp. 130-131
[75] Transcript. Vol. 7 , pp. 104-105; and Transcripts Vol. 6 pp. 99-102.

VII. NB's Criticisms of HONI's Proposal

134. In the course of responses to questions in cross-examination and questions posed in reply by its own counsel, NB witnesses made a number of criticisms of aspects of HONI's proposal for the LSL. Many if not all of the responses were made in violation of the rule in *Browne v. Dunn*.[76] The rule is that if counsel seeks to challenge the credibility of a witness in argument or by calling contradictory evidence, the witness must be given the opportunity to address the evidence or in the argument in cross-examination.

135. The rule is, at bottom, intended to ensure fairness. As the court in *Brown v. Dunn* put it:

> …if you intend to impeach a witness you are bound, whilst he is in the box, to give him an opportunity of making any explanation which is open to him; and as it seems to me, that is not only a rule of professional practice in the conduct of a case, but is essential to fair play and fair dealing with witnesses.[77]

136. In the context of this case, adherence to the rule is not just a matter of fairness, that is of allowing HONI witnesses the chance to respond to misstatements by NB witnesses. It is also important to ensure that the hearing panel has a full and balanced statement of the evidence on critical components of the competing LTC Applications.

137. Canadian courts have dealt with violations of the rule in *Browne v. Dunn* in two ways. One is to ask the adjudicator to give the statements made in violation of the rule no weight. The second is to recall the witnesses. HONI will adopt a third solution, which is to address herein the most egregious violations of the rule.

(i) Status of HONI's Work on Stations

138. NB's witnesses suggested that HONI's schedule for completion of the work on the Stations was slow and could be speeded up. Implicit in that was the suggestion that somehow HONI was slow-walking the work on the Stations in order to delay the in-service date for the EWT line.

[76] *Browne v. Dunn* (1892), (1894) 6 R.] (U.K.H.L.)
[77] Ibid., pp. 70-71

139. HONI's evidence, acknowledged by the witnesses from the MECP, and, curiously enough, acknowledged by NB's own witnesses, was that completing the work on the Stations was delayed because of the MECP's refusal to issue the permits necessary to complete the work.

140. In addition, and in response to Undertaking JT4.1[78], HONI's evidence was that, at best, the time required to complete the Station work could at the highest be reduced by four to six weeks, allowing the Stations work to be completed by August 2021.

141. NB further asserted that the work on the Stations could be speeded up by employing a number of measures that entailed additional costs. That suggestion is yet another example of NB's attitude to burdening ratepayers with added costs in order to meet a self-imposed in-service date.

142. Despite the fact that HONI explained on a few occasions the extensive scope of work at the three major stations, NB does not seem to understand the overall magnitude and sequence. Suggestions that adding more people to expedite the work is nonsensical when most of the work is consequential and requires full completion of a particular phase in a set location before the next phase can commence. While this work is undertaken, the integrity of the existing EWT circuits and transfers must be maintained and modifying the stations while keeping service intact requires precise coordination and planning.

(ii) HONI's Costs

143. NB created a table of what it claimed are HONI's "realistic costs" for the cost of constructing the EWT line. That table, which appears on page 55 of 69 of Attachment 3 to NB's response to OEB Staff Interrogatory 51, contains a number of misleading figures. Andrew Spencer, in his opening statement for HONI, addressed the inaccuracies in the table. Because of the emphasis NB places on the numbers in the table, and the use to which NB put the table, discussed below, Mr. Spencer's comments on the table need to be set out in full, as follows:

> MR. SPENCER: Through the review of the updated evidence provided on September 24th, HONI was aware of some incorrect statements that have been made and wants to provide clarity to the participants in this hearing. I will speak only to correct

[78] Undertaking JT4.1

misrepresentation of information about HONI's application and leave to others to confirm the NextBridge information that was provided is correct.

One example of assertions that has been filed in evidence appear in the form of this presentation which was provided to the chief of staff, to the Minister of Environment, Conservation, and Parks around August 31st, 2018. I will speak largely to the cost table that is shown on the screen and the misrepresentation of information.

The following is a subset of untrue statements made in reference to a minimum and maximum range of costs for HONI's project, and clarifications and corrections can be provided as follows: Firstly, the statement says HONI's realistic costs are higher than NextBridge's and could be as high as $1.1 billion without meeting policy and stakeholder objectives of a 2020 in-service date.

Based on an incredibly vast amount of evidence available for these applications, HONI's application is substantially lower cost than NextBridge's, no matter which way one looks at it.

Number two –

MR. SPENCER: I will continue, thank you.
So stepping through the key items in the table that's displayed on the screen, number two, NextBridge development spend to the end of August is $35.2 million. While true, and NextBridge has spent more than $75 million on this project to date, $35 million beyond what they have labelled as development costs, this is in no way a function of HONI's application and in no way affects our minimum or maximum price.

Thirdly, the cost to the electricity system if not in-service by 2020 with a range of 21- to $145 million. The assertion that our project cannot be in-service until 2024 is entirely incorrect as presented in evidence to be heard during this proceeding. We have demonstrated in multiple places, most notably Exhibit I, tab 1, schedule 7, how we can have the project in-service well before the required date of year-end 2022.

The range of additional system costs is misleading and erroneous in that it ignores the simple economics that a deferred in-service is actually a customer benefit from a rate-making perspective. That is, HONI's project, even accounting for the potential system costs, will produce ratepayer benefits up until 2025. This was provided in response to PW6 at Exhibit I, tab 6, schedule 6. Further

information can be found at Exhibit I, tab 1, schedule 17, as well as Exhibit I, tab 5, schedule 22.

Number four, HONI may have additional costs of up to $79 million due to admitted inflation or escalation costs. This is certainly not the case. All costs within HONI's application are presented in nominal dollars. There are zero omitted costs due to escalation. The only exceptions are in Exhibit B, tab 9, schedule 1 and Exhibit I, tab 5, schedule 22, where figures comparing the economics of the two applications are expressed in present value dollars.

Number five, due to a difference in the AACE estimate classification, HONI's costs could be as high as $64 million higher than the upper bound of NextBridge's cost estimate. HONI has provided evidence through multiple references regarding the nature of the pricing structure, and this information ought to have been well known to NextBridge. The most specific and relevant reference at the end of August is in Exhibit JT2.25, filed May 25th, in which HONI articulates an upper bound of 6 percent above nominal costs.

Number six, on page 3 of the presentation regarding HONI's approach and plan for Indigenous consultation and participation, which certainly are presented out of context and inconsistent with HONI's evidence. For example, the statement that HONI Networks Inc.'s leave to construct did not include any cost for Indigenous participation, which means $7 million of costs are missing from HONI's leave to construct, is factually incorrect. As presented in Exhibit TCJ2.21, HONI has in fact budgeted over $18 million, more than double what NextBridge has for the economic participation in the construction phase of the project. This is in addition to the envisioned enhanced participation through Indigenous partnership and ownership of the Lake Superior link, as outlined on page 12 of HONI's additional evidence to the motion to dismiss filed May 7th.

Ms. Goulais will provide evidence on these matters in her testimony.

Number 7; if HONI Networks is not allowed to go through the park, Pukaskwa National Park, an additional cost of $80 million should be expected. Aside from selective information provided out of context, the incremental figure of $80 million is wrong. The correct figure, as presented in Exhibit JT2.23, is approximately $37 million.

> Number 8; as part of NextBridge's construction cost estimate, a contingency amount was included of 6 percent. HONI has only included a contingency of 1.5 percent. This information is incorrect, and HONI presented correct figures in multiple places, including Exhibit B, tab 7, schedule 1, table 3 in February, as well as in Exhibit JT 2.21 in May. HONI has a contingency of 10.2 percent, or $64 million.[79]

144. NB provided this misleading data by fax to the MECP, accompanied by an outline of the "facts" related to the competing LTC Applications. That outline also contains statements which are simply not true. For example, NB asserts that "Government issued an Order-in-Council in 2016 for a 2020 in-service date". The Order-in-Council did not order that the EWT line be in service by 2020, as the OEB found in its decision dismissing the NB Motion.[80]

145. NB has continued to insist that the OIC required that the EWT line be in-service by 2020. For example, in response to a question from Mr. Murray about NB's position that it was required to have the line in service by 2020, Ms. Tidmarsh said "It was our understanding from the order in council for a December 2020 date, the needs assessments from the IESO."[81]

146. The OEB, in its "Decision and Order" dated July 19, 2018, made the following finding, at p. 7:

> The OEB is persuaded that, on a plain reading of the Priority Project OIC, the priority project declaration is not tied to a 2020 in-service date. The OEB notes in particular that the 2020 in-service date is not captured within the definition of the "East-West Tie Line Project" that was declared a priority. This is consistent with the IESO's Updated Needs Assessment that recommends (but does not require) that the project be in service by 2020.[82]

147. That NB would deliberately mislead the Government about the facts of the competing LTC Applications is troubling in itself and also gives rise to the question of how much of NB's purported public support is also based on misleading information.

[79] Transcript, Vol. 1, p. 26 ff.
[80] EB-2017-0364, Ontario Energy Board "Decision and Order" dated July 19, 2018.
[81] Transcript, Vol. 7, p. 22.
[82] EB-2017-0364, Ontario Energy Board "Decision and Order" dated July 19, 2018, p. 7.

(iii) Technical Compliance

148. One NB witness stated that NB was not taking the position that HONI's application did not meet the OEB's technical requirements[83]. However, NB's witness subsequently asserted, in response to questions from members of the hearing panel, that HONI's EWT line did not meet the OEB's requirements with respect to galloping.[84]

149. Both assertions are untrue. The Lake Superior Link design is a modern design that complies with the OEB specifications, Canadian Standards and relevant industry practices and norms in a cost effective manner, the details of which are explained below.

150. The OEB Minimum Technical Requirements for the Reference Option of the E-W Tie Line dated November 9th, 2011, is prefaced with *"This document is not intended as a detailed design specification or as an instruction manual for the E-W Tie Line and this document shall not be used for those purposes. The designated transmitter, its employees or agents must recognize that they are, at all times, solely responsible for the design, construction and operation of the E-W Tie."* The galloping criteria are addressed in article 3.6.4 which states "*Galloping clearances are to be considered in development of the general structure configuration for voltages at or above 230kV. This analysis shall consider single loop galloping, regardless of span length, with a primary axis limited to a maximum of 12m (Lilien & Havard, Cigre TF B2.11.06)"*.

151. Provided in Attachment 1 is a paper by Lilien & Havard, Cigre TF B2.11.06 which describes in detail the causes and prevention options to be considered for galloping at various voltages one of which includes interphase spacers. On page 47, it explains the engineering practice to design against galloping and references the Rural Electrification Administration (REA) guide. This Bulletin 1724E-200 dated May 2009 states in article 6.5.1 (p6-7) "*Single-loop galloping rarely occurs in spans over 600 to 700 feet. This is fortunate since it would be impractical to provide clearances large enough in long spans to prevent the possibility of contact between phases*". REA is based on a combination of the A.E. Davison method for single loop galloping and the L. W. Toye method for double loop galloping.

[83] Transcript, Vol. 5, p. 47, lines 6-14.
[84] Transcript, Vol. 7, pp. 43, 45, 86.

152. In September 2013, Dr. Havard (co-author of the Lilien & Havard TF B2.11.06 of November 9, 2011) presented the Tower Head Design for Galloping Based on New CIGRÉ Criteria and on page 4 presented an example of the use of the modified ellipse for *"a newly designed line in Canada. The results are shorter towers with shorter arms, and narrower rights of way and the significant savings in line cost"*…. *"The position of the utility involved is to have interphase spacers as a backup alternative for those spans that are found to be seriously affected by galloping"*. The paper also concluded on pages 7-8 that *"The new towers are more slender and shorter resulting in reduced weight, cost and right of way requirements"*. This CIGRE paper is attached as Attachment 2 and is the basis of the HONI design for the E-W Tie line.

153. HONI meets the OEB Minimum Technical requirements by considering the Galloping Clearances in its general structure configuration including the effects of single loop galloping. However in its design, HONI also considers the years of data on the existing E-W Tie on flashover data as well as most recent studies which recommends the mitigation of the galloping phenomenon by incorporating design methods that reduce economic impacts. This allows a design that mitigates the Galloping Phenomenon as well as provides a structure design that is more slender and shorter enabling reduced weight and right of way requirements resulting in an overall lower cost design, that is to the benefit of the ratepayers of Ontario.

(iv) HONI EPC Contract

154. NB's witnesses claimed that HONI's EPC contract with SNC-Lavalin had not been signed because there would be changes in the contract prior to its execution. That proposition was not put to the witnesses from HONI and SNC-Lavalin. The unchallenged evidence of both HONI and SNC-Lavalin was that the contract would be signed in its existing form when leave to construct is granted.

(v) The Status of HONI's Project

155. NB's witnesses repeatedly and inaccurately suggested that HONI's project was "not well developed". HONI's project may not be as advanced as that of NB's, but the evidence has shown that HONI's project is well underway in all aspects and is on target to meet a 2021 in-service date.

156. HONI has extensive experience in building, operating, and maintaining transmission lines throughout Ontario. NB, on the other hand, has no experience in building, operating and maintaining transmission lines anywhere in Ontario. The evidence of NB was that it would have two full-time employees in Ontario, one of whom would be responsible for vegetation management; and NB also stated that it would contract with external providers for repair and maintenance assistance as needed. Comparing such an arrangement with HONI's more than a century of experience and its vast operating and maintenance network, and its vast employee strength, throughout Ontario, including the North, is a futile task that should be of great concern to consumers and to the OEB's principles of reliability and quality of service.

(vi) Crossings

157. NB witnesses suggested that HONI had impeded progress in resolving the issues related to crossings. The implication that any delay and additional cost occasioned by the need to resolve these issues was HONI's fault was never put to HONI's witnesses and is untrue.

158. HONI has met with NB on this topic since April 2016, has provided requirement details for crossing, and has always objected to NB's proposed crossings due to reliability and safety risks. This resulted in NB revising its route and reducing the number of crossings in Q1 of 2017. HONI provided all requirements to NB relative to two sections of the T1M line that need to be relocated. These sections of T1M need to be relocated to eliminate reliability and safety risks. Importantly, in order to effectively complete the mandated future upgrade of the transmission line to meet a to 650MW transfer limit, work will be required on T1M. Not relocating the T1M facilities now will impede this future work, resulting in increased costs to ratepayers.

159. In informing NB of HONI's requirement for NB's line not to cross directly over its structures, HONI's position has not changed and has always been to maintain a minimum 15 metre or 50-foot buffer around its structures. This is required not only during construction (e.g., its access roads, construction areas, etc.) but also when designing the separation between its proposed line (structures and conductors) and HONI structures. NB was aware of and understood these requirements. NB's own drawings, dated August 2016, provided for ease of reference as Attachment 3 of this argument-in-chief, explicitly documented this 15-metre buffer.

160. NB's current proposed crossings come closer than 15 metres to HONI structures, with no apparent intention by NB to meet the requirements. NB is wrongly claiming that this is a new and revised requirement; HONI disagrees, and NB's own drawings confirm that this is not new information. The HONI requirements are in place to allow for safe and reliable operation and maintenance practices. Failure to adhere to these requirements jeopardizes HONI work methods and exposes, unnecessarily, the local area supply to increased reliability risk.

161. After HONI filed its LTC Application, NB effectively ceased to collaborate on the matter of crossings. In April 2018, after repeated requests from HONI to NB to rectify the NB design, NB's Jennifer Tidmarsh informed HONI that NB has no intention to meet or comply with HONI requirements. The OEB EWT Line Minimum Technical Requirements, specifically, section 3.1.5 outlines that "…special clearances or other requirements as established by governing authority of these facilities may be required. These clearance or other requirements must be adhered to in the design and construction of the transmission line". Despite the fact that NB claims it meets the OEB requirements, testimony provides explicit evidence that NB intends to file a Section 101 application to seek to ignore these HONI requirements.

VIII. Conclusion

162. HONI submits that the Stations Application should be granted because it has satisfied the criteria of sections 92 and 96 of the OEBA. No aspect of the Stations Application has been challenged.

163. HONI submits that the HONI LTC Application should be granted. The application satisfies the criteria of sections 92 and 96 of the OEBA with respect to price, reliability and quality of service. In any other situation, if two alternatives were presented, both offering the same reliability and quality of service, but one with substantially lower costs – the decision would be obvious. HONI submits that its application should be granted subject only to the standard conditions, including obtaining approval for any required environmental assessments.

164. HONI submits that NB's LTC Application should be dismissed. NB's proposed EWT line is substantially more expensive to build than HONI's, and substantially costlier to operate and maintain on an ongoing basis. In addition, NB is proposing to build a line that

cannot be in service until 2021, and to charge more, by its own admission, to do so. In the circumstances, HONI submits that there is no valid reason to grant NB's application.

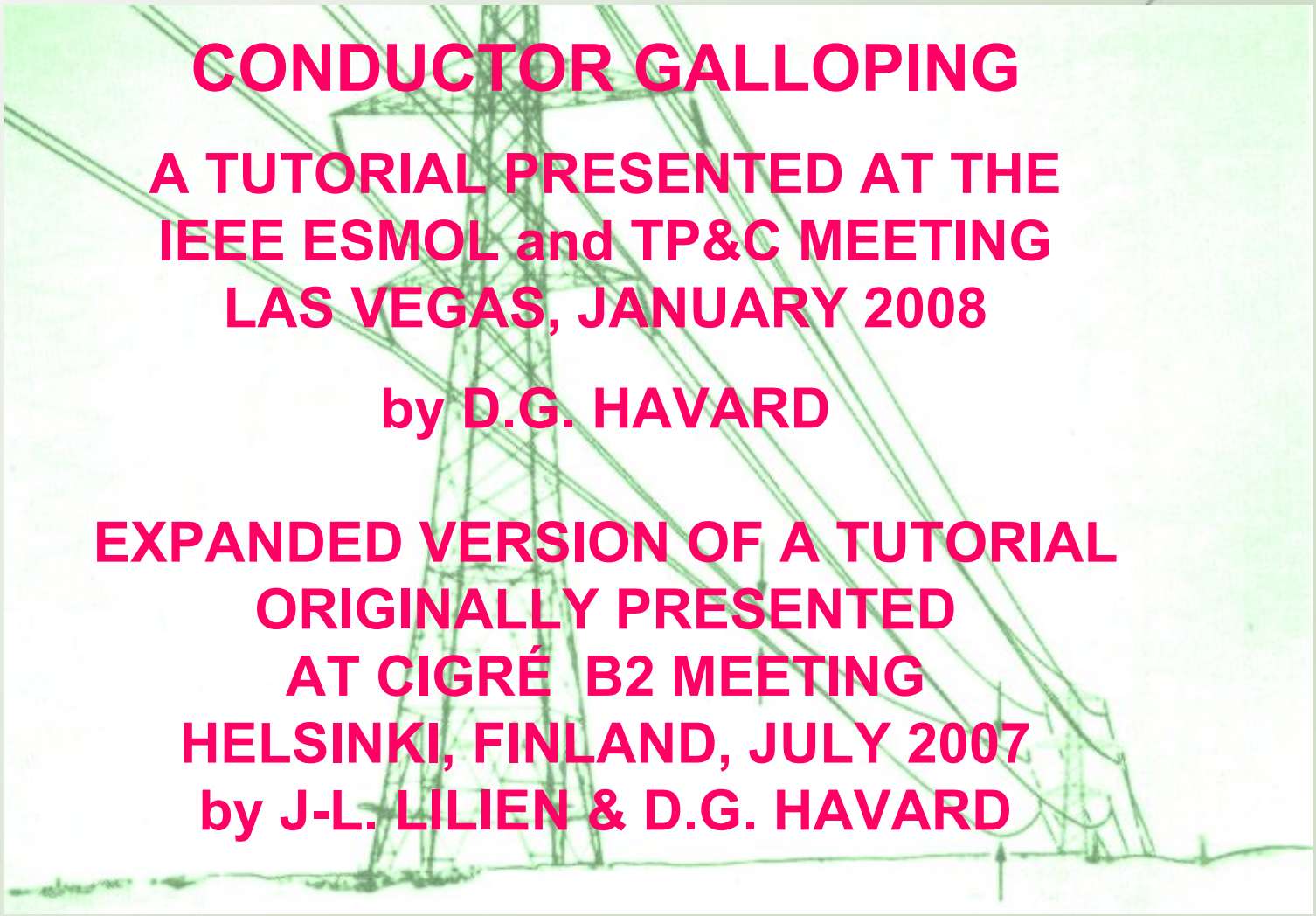
165. Finally, HONI submits that NB should not be allowed to recover the construction costs it has spent to date since filing its leave to construct application in July of 2017 to the granting of the leave to construct. By NB's own admission, it is at risk for those costs. There is no justification for allowing NB to recover them, in fairness to consumers and observance of the scope of the OEB's Decision in the Designation Proceeding.

ALL OF WHICH IS RESPECTFULLY SUBMITTED

Robert B. Warren
Counsel to HONI Networks Inc.

12315163.3

ATTACHMENT 1
TO HYDRO ONE NETWORKS INC. ARGUMENT-IN-CHIEF
DATED OCTOBER 22, 2018



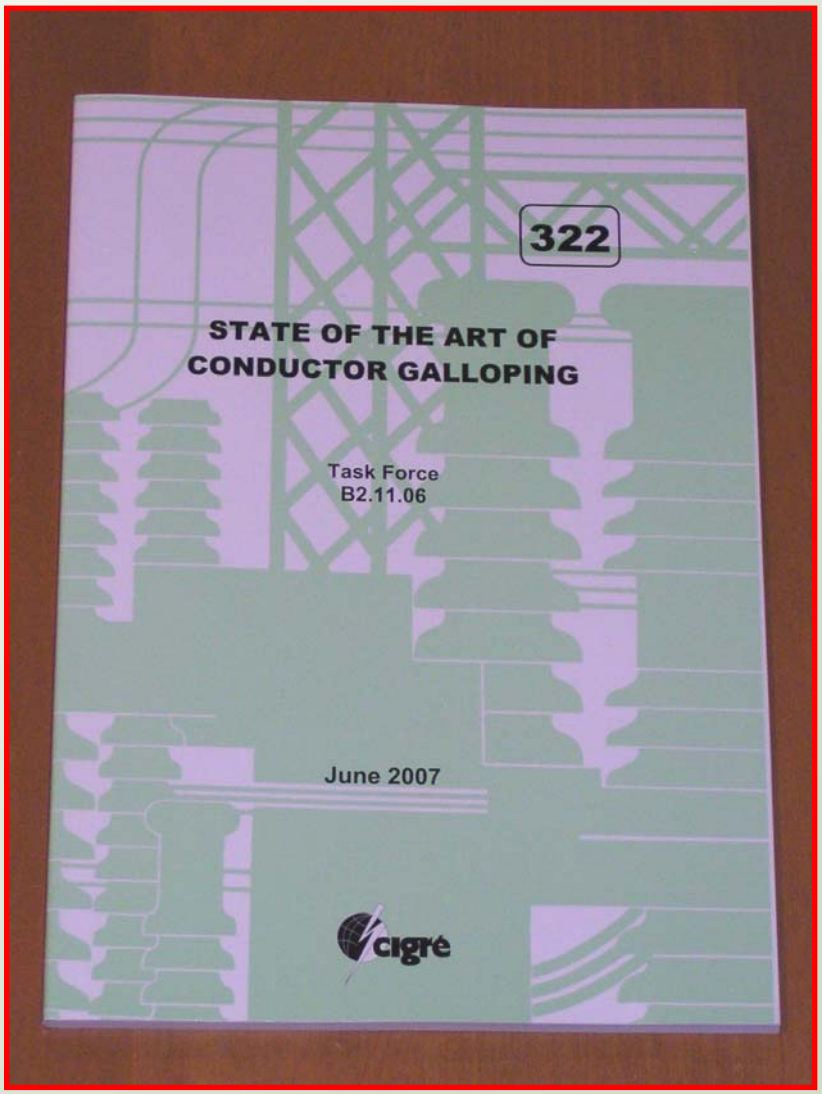
CONDUCTOR GALLOPING

A TUTORIAL PRESENTED AT THE IEEE ESMOL and TP&C MEETING LAS VEGAS, JANUARY 2008

by D.G. HAVARD

EXPANDED VERSION OF A TUTORIAL ORIGINALLY PRESENTED AT CIGRÉ B2 MEETING HELSINKI, FINLAND, JULY 2007

by J-L. LILIEN & D.G. HAVARD



TUTORIAL IS BASED ON CIGRÉ TECHNICAL BROCHURE NO. 322

"STATE OF THE ART OF CONDUCTOR GALLOPING"

OBTAINABLE FROM CIGRÉ (www.cigre.org)

146 PAGES

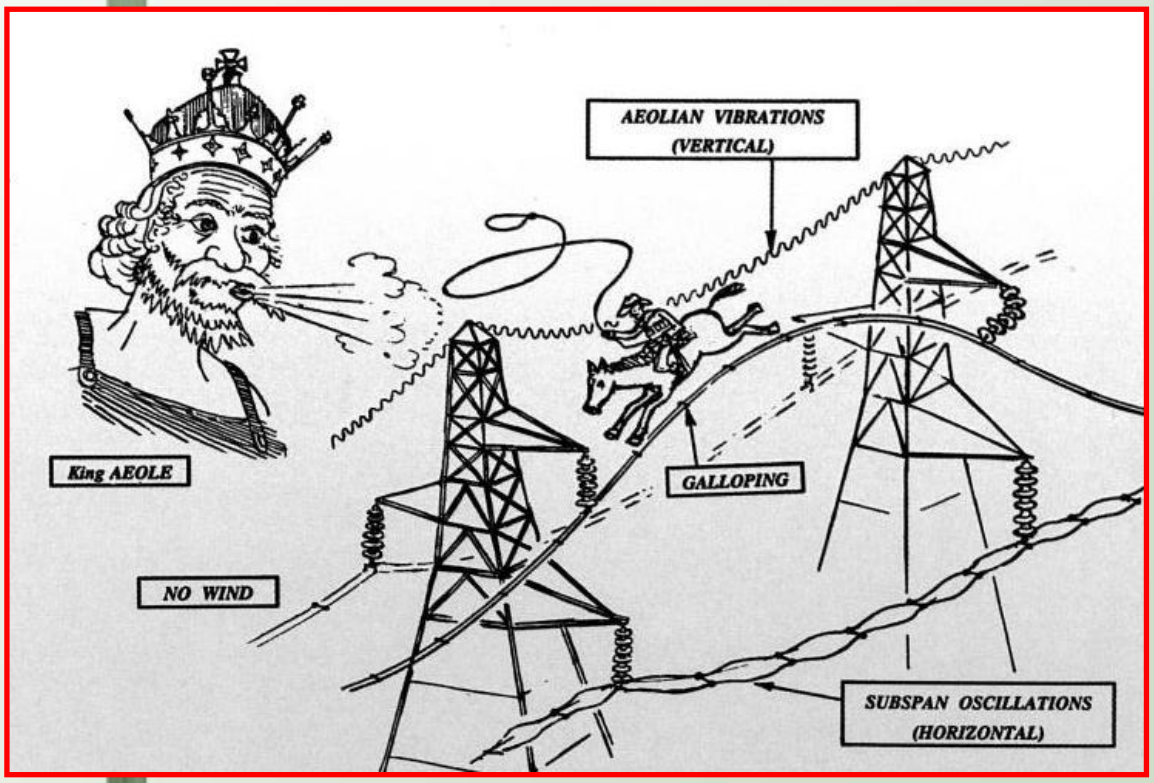
MEMBERS €70

NON MEMBERS €140

OUTLINE OF THE TUTORIAL

- *WHAT IS GALLOPING?*
- *CONDITIONS FOR GALLOPING*
- *VIDEOS OF GALLOPING*
- *MECHANICS OF GALLOPING*
- *DAMAGE DUE TO GALLOPING DYNAMIC LOADS DUE TO GALLOPING*
- *CONTROL OF GALLOPING*
- *FIELD DATA ON EFFECTIVENESS OF CONTROLS*
- *DESIGN CLEARANCES TO AVOID CLASHING DURING GALLOPING*
- *CONCLUSIONS*

WHAT IS GALLOPING?



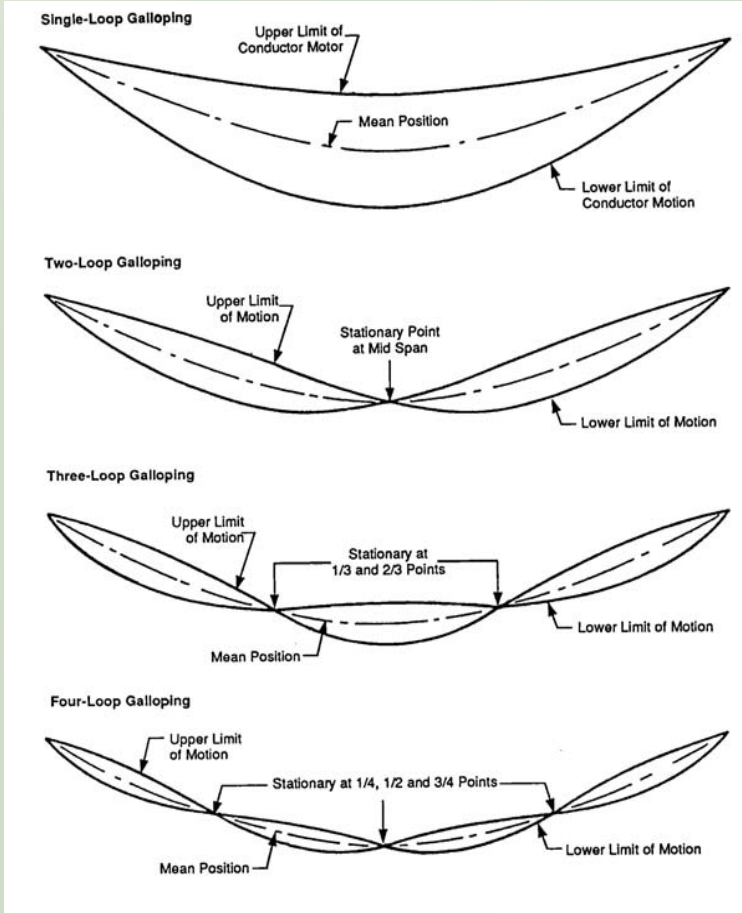
GALLOPING IS:

- *A WIND-INDUCED VIBRATION OF BOTH SINGLE AND BUNDLE CONDUCTORS*
- *DIFFERENT FROM AEOLIAN VIBRATION AND WAKE INDUCED OSCILLATION*
- *LOW-FREQUENCY (FROM 0.1 TO 1 HZ)*
- *LARGE VERTICAL AMPLITUDE (FROM ± 0.1 TO < ± 1 TIMES THE SAG)*

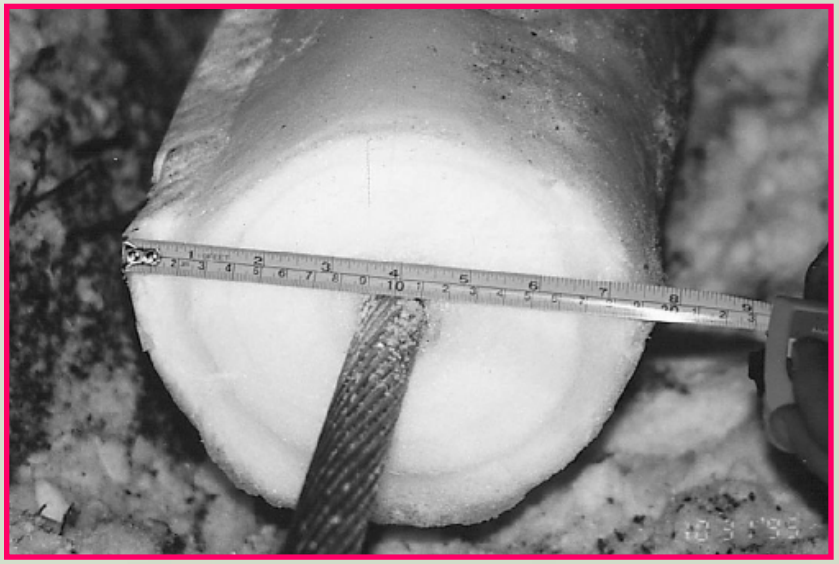
- *UP TO 4 TIMES THE SAG ON DISTRIBUTION LINES*
- *A SINGLE OR A FEW LOOPS OF STANDING WAVES PER SPAN*
- *IT APPLIES VERY LARGE DYNAMIC LOADS TO THE STRUCTURES*
- *IT IS A SELF-EXCITED PHENOMENON*

CONDITIONS FOR GALLOPING - ICE

- *GLAZE ICE, RIME ICE OR WET SNOW ON THE CONDUCTORS (THE ICE LAYER NEED NOT BE THICK)*
- *GALLOPING CAN OCCUR WITHOUT ICE ON RARE OCCASIONS*
- *GALLOPING APPEARANCE (NUMBER OF LOOPS, AND PEAK TO PEAK AMPLITUDE)*
- *CAN BE DIFFERENT ON APPARENTLY SIMILAR CONDUCTORS WITHIN THE SAME SPAN*



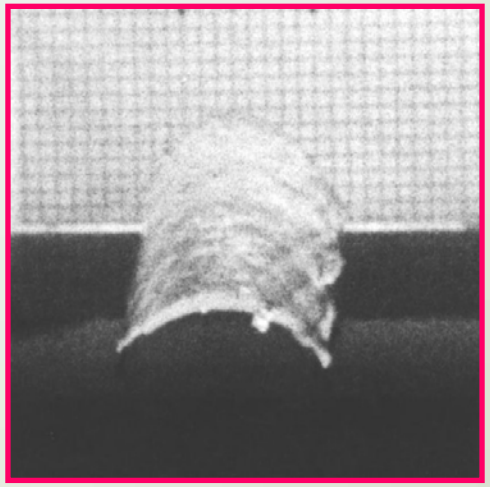
ICE ACCRETION

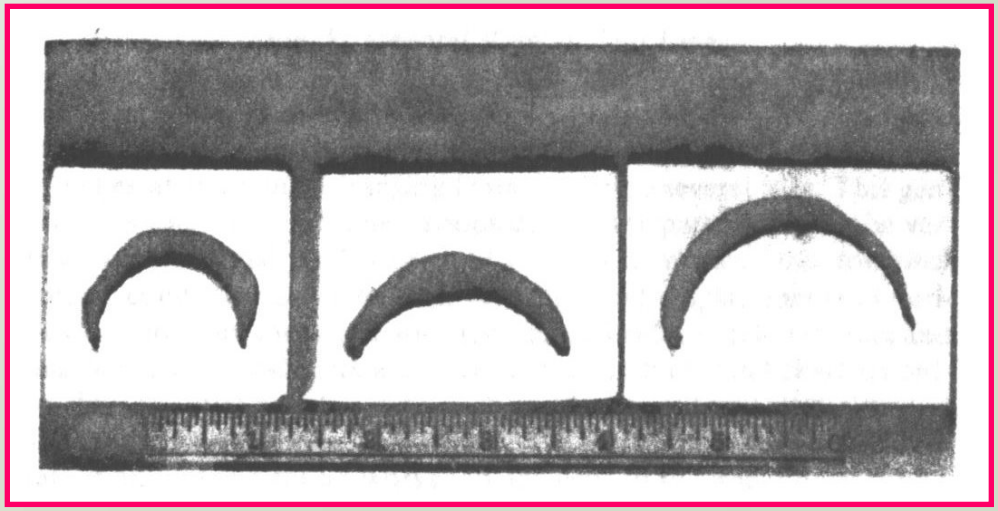


WET SNOW SHAPES

- *SHOWING NORMAL ROUGH TEXTURE*
- *ROUNDED PROFILE ON SMALL CONDUCTOR DUE TO CONTINUOUS ROTATION*

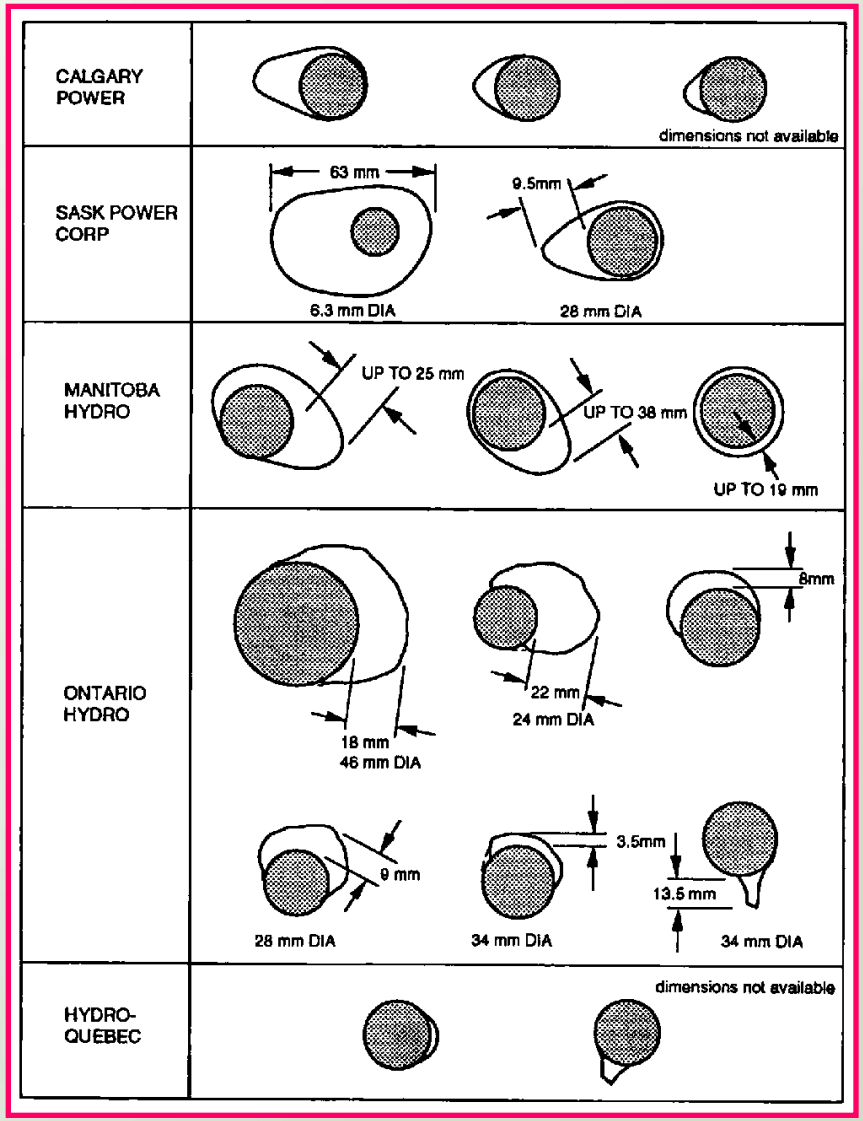
ICE ACCRETION





GLAZE ICE SHAPES FROM SINGLE CONDUCTORS AFTER GALLOPING EVENTS

SHOWING THINNESS OF ICE LAYERS



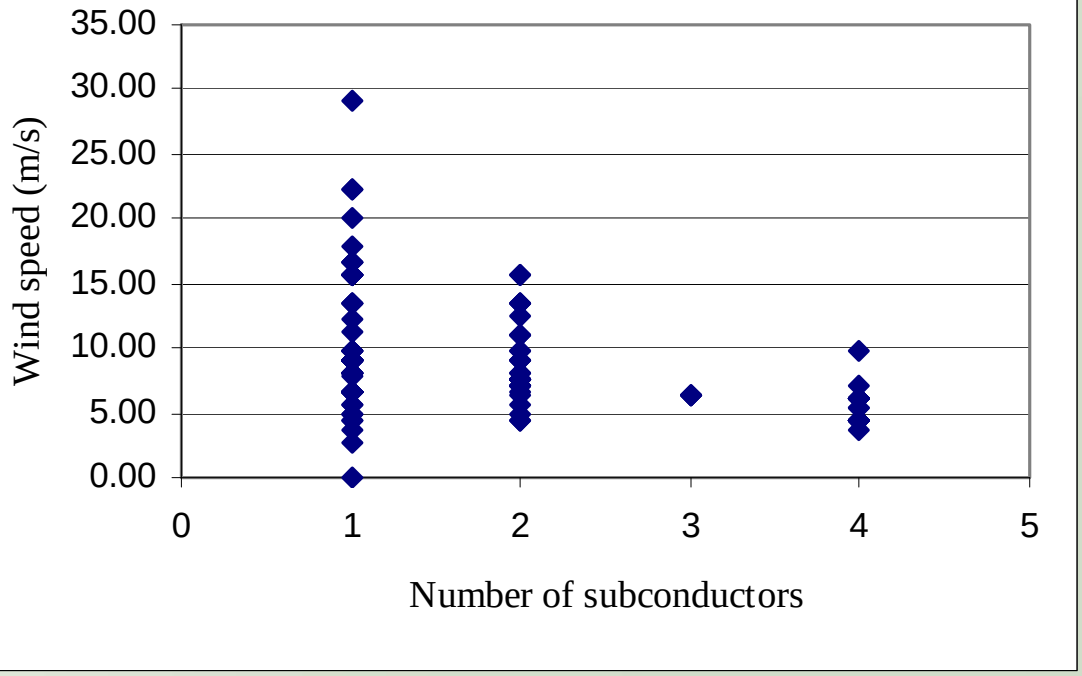
SHAPES OF ICE ACCRETION ON CONDUCTORS DURING GALLOPING

- *REPORTED IN SURVEY OF CANADIAN ELECTRICAL UTILITIES*
- *NOTE WIDE VARIATION IN AMOUNT OF ICE AND SEVERAL CASES WITH VERY THIN ICE LAYERS*

CONDITIONS FOR GALLOPING - WIND

- *MODERATE TO HIGH WIND SPEEDS*
- *STEADY WINDS*
- *WIND TRANSVERSE TO THE LINE*
- *OPEN EXPOSURE OF THE LINE (LOW TURBULENCE)*
- *RIVER CROSSINGS AND LINES ALONG LAKE FRONTS ARE PARTICULARLY SUSCEPTIBLE*
- *CAN LAST FOR A FEW HOURS OR SEVERAL DAYS*

WIND SPEEDS FOR GALLOPING



WIND SPEEDS REPORTED DURING GALLOPING FOR SINGLE, TWIN, TRIPLE, AND QUAD BUNDLES

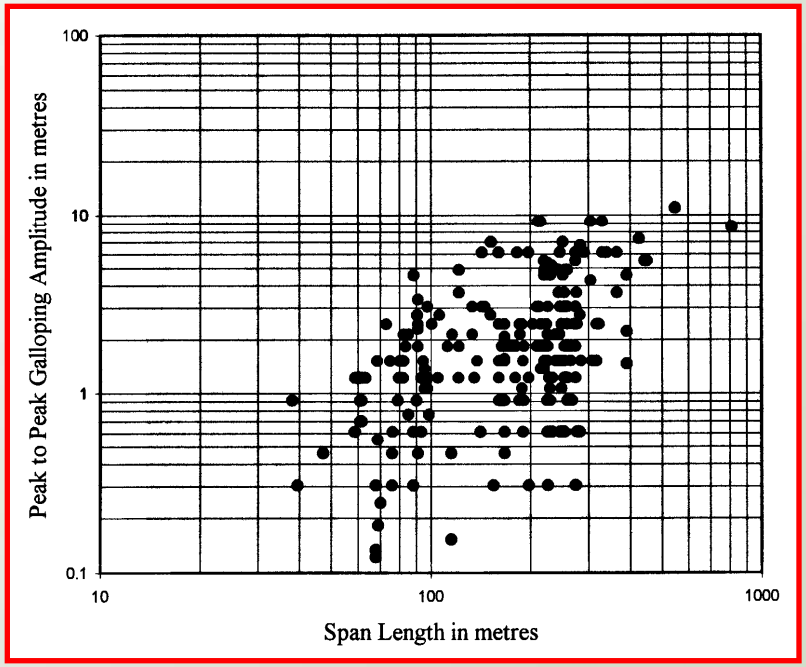
MOST GALLOPING OCCURS AT WINDS SPEEDS ABOVE 5 m/s ON SINGLE AND BUNDLE CONDUCTORS

VIDEO OF GALLOPING - SINGLE CONDUCTOR LINE IN NORWAY

VIDEO OF GALLOPING – TWIN BUNDLE IN ENGLAND

VIDEO OF GALLOPING – QUAD BUNDLE IN JAPAN

GALLOPING AMPLITUDES

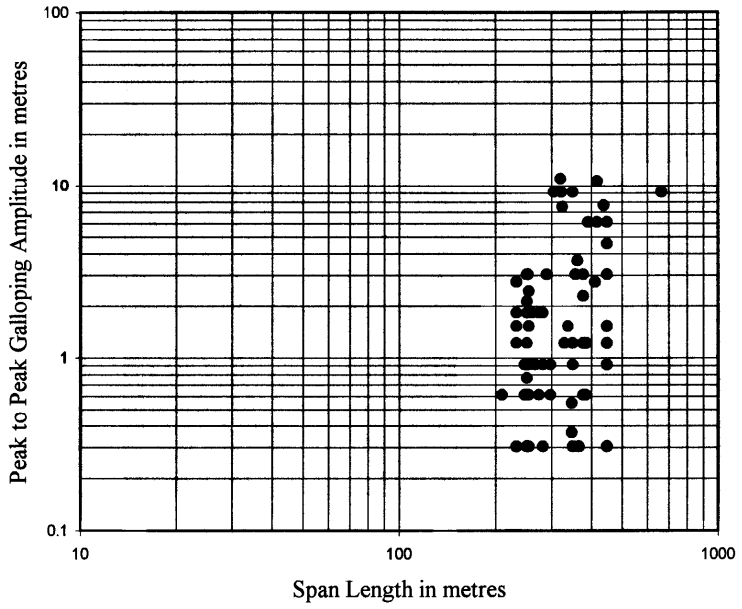


ABOVE: SINGLE CONDUCTORS

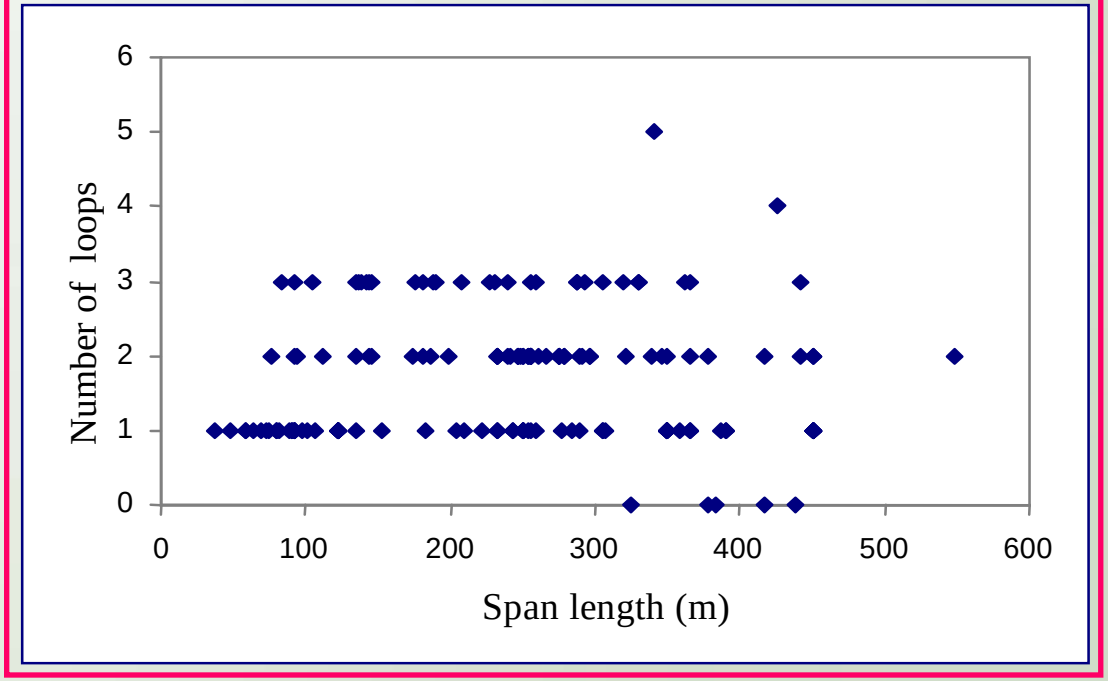
RIGHT: BUNDLE CONDUCTORS

(FROM FIELD STUDIES IN USA AND CANADA)

PEAK TO PEAK GALLOPING AMPLITUDES VERSUS SPAN LENGTH OBSERVED IN THE FIELD



NUMBER OF GALLOPING LOOPS



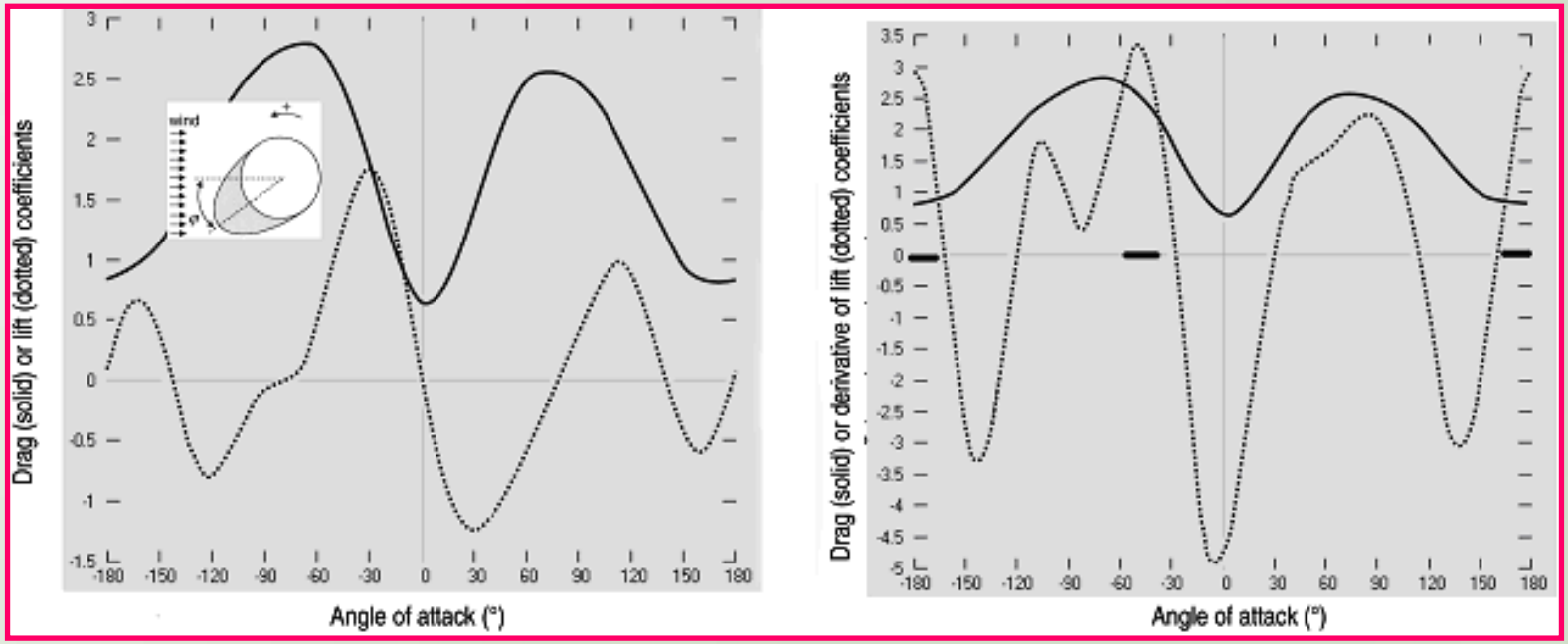
NUMBER OF LOOPS OBSERVED DURING GALLOPING VERSUS SPAN LENGTH

- *BASED ON ANALYSIS OF FIELD DATA FROM ALL GALLOPING OBSERVATIONS*
- *DATA FROM SINGLE AND BUNDLE CONDUCTOR SITES*
- *SHOWS THAT SINGLE LOOP GALLOPING CAN OCCUR ON LONG SPANS*
- *GALLOPING CAN INCLUDE TRAVELING WAVES*

DEN HARTOG MECHANISM

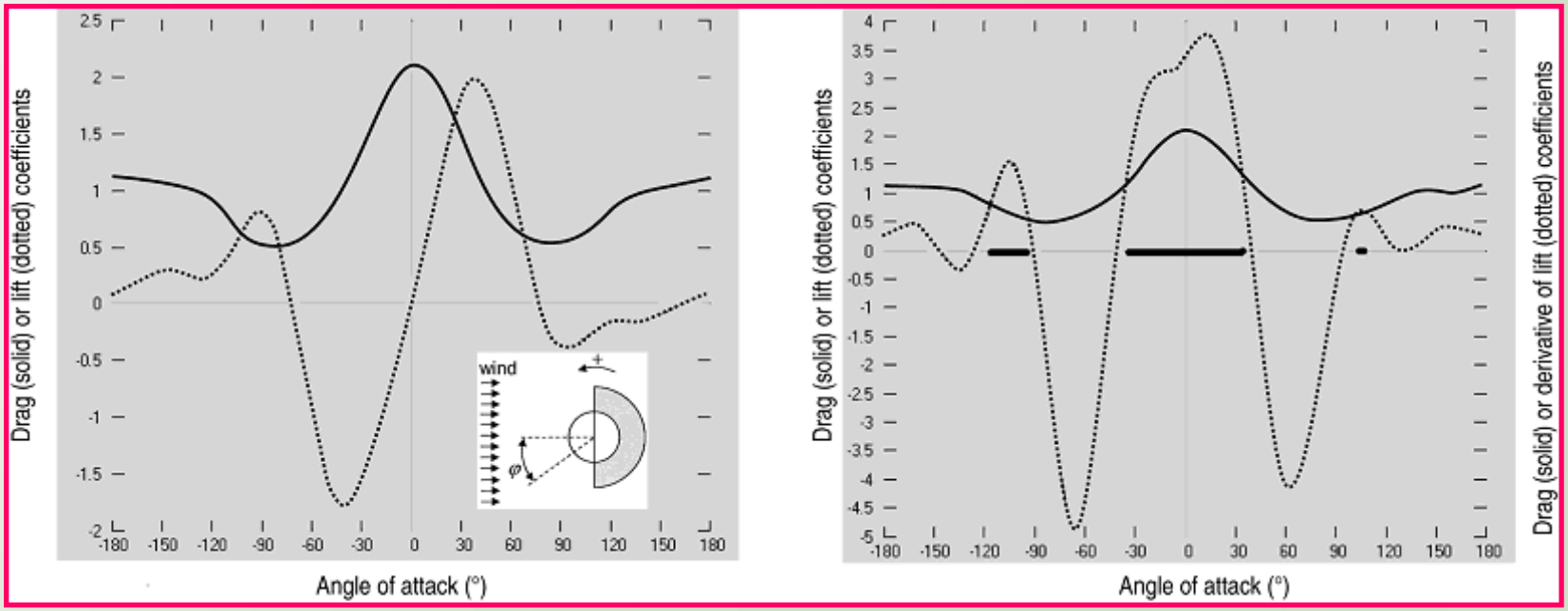
- *ONLY AERODYNAMIC FORCES ARE IMPORTANT*
- *PREDICTS GALLOPING WHEN SLOPE OF THE LIFT COEFFICIENT CURVE (DOTTED) IS GREATER THAN THE DRAG COEFFICIENT (SOLID)*

$$C_D - C_{L\alpha} < 0$$



- *TORSION IS EITHER NEGLIGIBLE OR FORCED BY VERTICAL MOVEMENT*
- *TORSIONAL FREQUENCY AND DAMPING NOT IMPORTANT*
- *PROBABLY RARE, EXCEPT FOR REVERSE WIND*

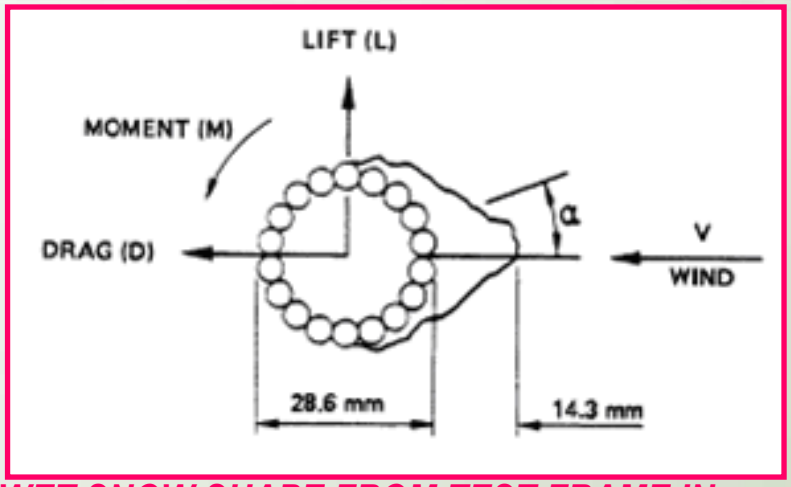
AERODYNAMIC PROPERTIES OF "D" SECTION



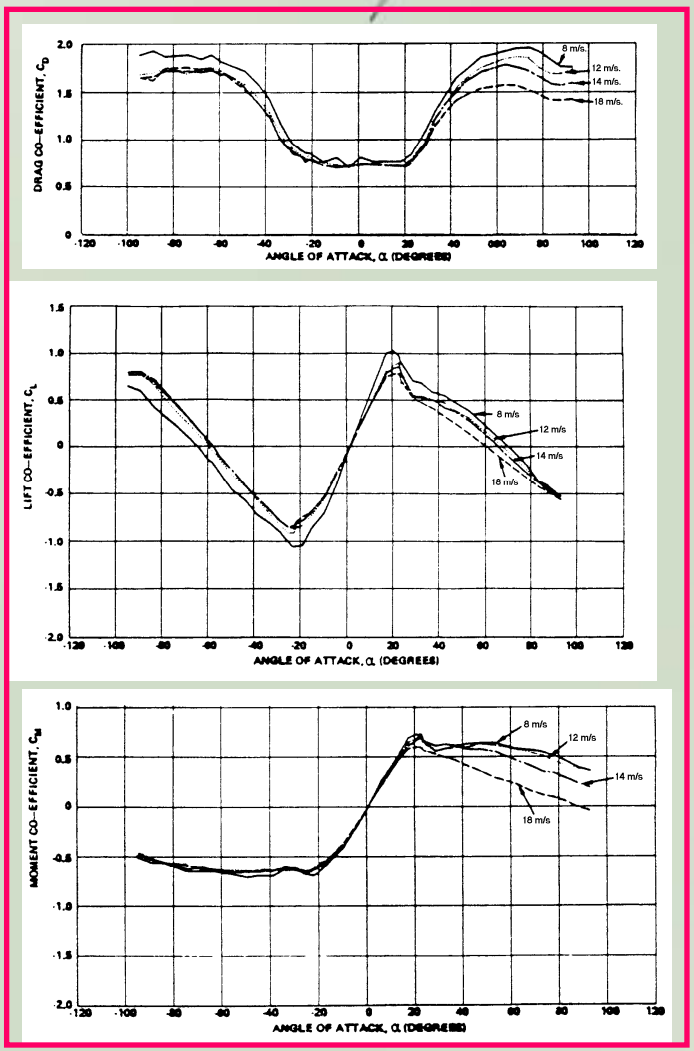
LEFT: LIFT AND DRAG COEFFICIENTS VERSUS ANGLE OF ATTACK, INSET SHOWS "D" PROFILE USED ON HYDRO QUÉBEC TEST LINE

RIGHT: RATE OF CHANGE OF LIFT AND DRAG COEFFICIENTS WITH DEN HARTOG INSTABILITY REGIONS

AERODYNAMICS OF ICE SHAPES

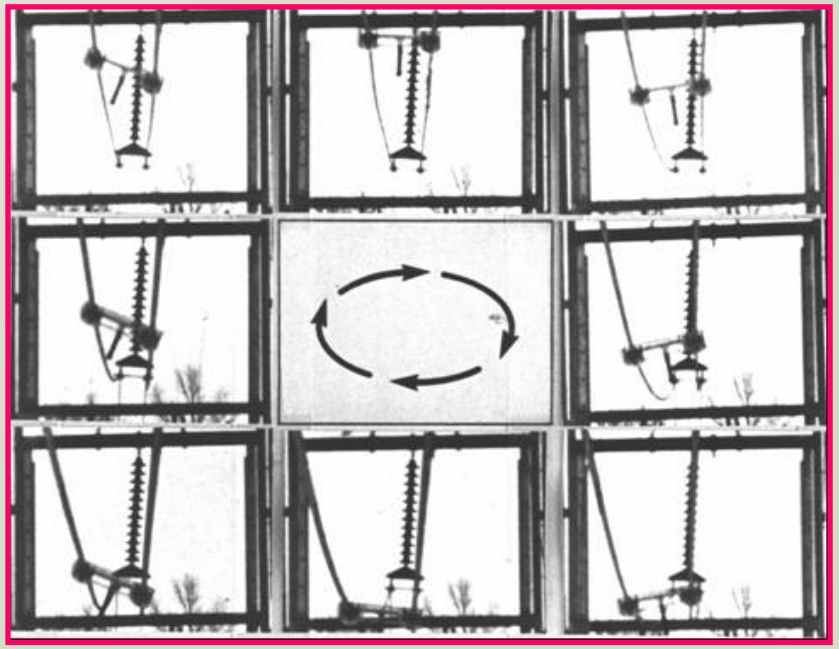


- *WET SNOW SHAPE FROM TEST FRAME IN ENGLAND*
- *AERODYNAMIC DRAG, LIFT AND MOMENT VERSUS ANGLE OF ATTACK DRIVE THE INSTABILITY (REVERSED SIGN OF ANGLE OF ATTACK)*
- *NEGATIVE SLOPE OF THE LIFT CURVE INDICATES SELF EXCITED OSCILLATIONS OF THE PROFILE*
- *ROTATION OF THE SECTION INCREASES THE RANGE OF UNSTABLE POSITIONS OF THE ICE*



FLUTTER MECHANISM

- *COUPLING BETWEEN VERTICAL AND TORSIONAL MOVEMENT IS CENTRAL TO THE MECHANISM*
- *TORSION IS ESSENTIAL FOR ENERGY TRANSFER TO VERTICAL MOVEMENT*
- *STRUCTURAL DATA AND AERODYNAMICS IMPORTANT*
- *RATIO VERTICAL TO TORSIONAL FREQUENCY IMPORTANT*
- *CONTROL OF TORSION BY DAMPING OR DETUNING IS ESSENTIAL FOR CONTROL*
- *PROBABLY THE MOST COMMON MECHANISM, PARTICULARLY ON BUNDLE CONDUCTOR LINES*



$$(C_D - C_{L\alpha})\frac{\omega y_{\max}}{V} < C_{L\alpha}.\vartheta_{\max}.\sin\phi$$

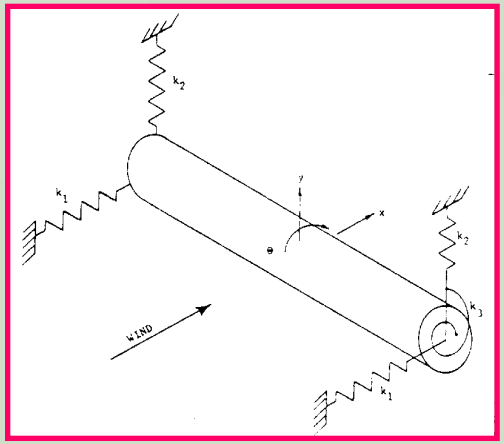
PREDICTION OF GALLOPING MOTIONS

$$\begin{bmatrix} \text{INERTIA} & & \\ m & & me_y \\ & m & me_x \\ me_y & me_x & I \end{bmatrix} \begin{Bmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{\theta} \end{Bmatrix} + \begin{bmatrix} \text{SPRINGS} & & \\ k_{xx} & k_{xy} & \\ k_{yx} & k_{yy} & \\ & & K_{\theta\theta} \end{bmatrix} \begin{Bmatrix} x \\ y \\ \theta \end{Bmatrix}$$

$$+ \begin{bmatrix} R_x & \text{MECHANICAL} & \\ & \text{DAMPING} & \\ & R_y & \\ & & R_\theta \end{bmatrix} \begin{Bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{Bmatrix} - \begin{bmatrix} 0 & \text{ICE WEIGHT} & \\ & & \\ & 0 & \\ & & We_y \end{bmatrix} \begin{Bmatrix} x \\ y \\ \theta \end{Bmatrix}$$

$$-\frac{\rho d V^2}{2} \begin{bmatrix} 0 & & C_{D\alpha} \\ & 0 & C_{L\alpha} \\ \text{AERO-} & & dC_{M\alpha} \\ \text{ELASTIC} & & \end{bmatrix} \begin{Bmatrix} x \\ y \\ \theta \end{Bmatrix} + \frac{\rho d V}{2} \begin{bmatrix} \text{AERODYNAMIC DAMPING} & & \\ VC_{DV}+2C_D & C_{D\alpha}-C_L & \\ VC_{LV}+2C_L & C_{L\alpha}+C_D & \\ d(VC_{MV}+2C_M) & dC_{M\alpha} & dVC_{M\dot{\alpha}} \end{bmatrix} \begin{Bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{Bmatrix}$$

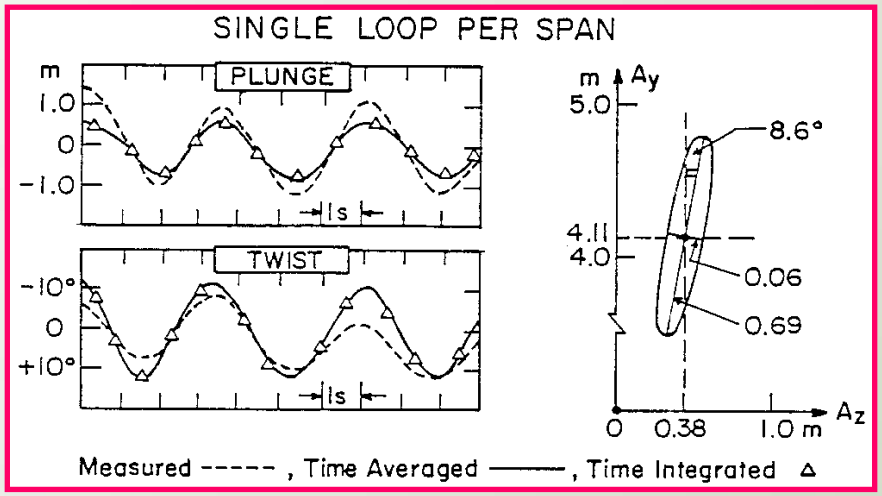
$$= \begin{Bmatrix} 0 \end{Bmatrix}$$

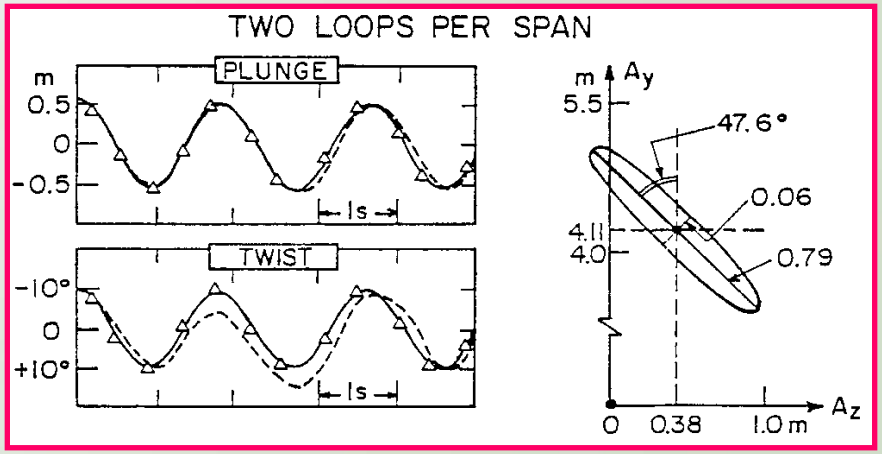


LUMPED MASS MODEL OF GALLOPING CONDUCTOR

- *EQUATIONS REPRESENTING LINEARIZED GALLOPING INCLUDING HORIZONTAL, VERTICAL AND TORSIONAL MOTIONS, BUT NOT LONGITUDINAL MOTIONS*
- *THIS PRESENTATION IDENTIFIES THE INERTIA EFFECTS, SPRING FORCES, DAMPING, AND WEIGHT AND AERODYNAMIC FACTORS (RAWLINS 1979)*

PREDICTION OF GALLOPING MOTIONS





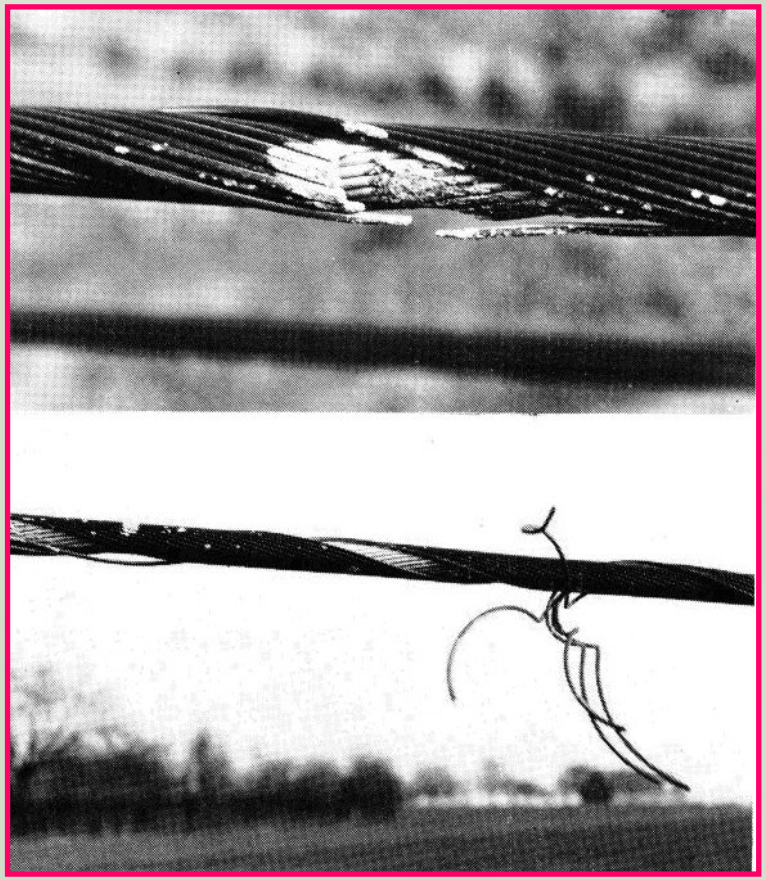
- *COMPARISONS OF FINITE ELEMENT PREDICTION AND MEASURED SINGLE AND TWO -LOOP GALLOPING MOTIONS OF A SECTION OF ICED CONDUCTOR MODEL IN A WIND TUNNEL*
- *ICE WAS REPRESENTED BY A SMOOTH ELLIPTICAL PLASTIC FOIL ON THE WINDWARD SIDE OF THE CONDUCTOR*
- *SIMULATION OF ACTUAL LINES REQUIRES MODELING OF SEVERAL SPANS TOGETHER AND DATA ON THE ICE OR WET SNOW SHAPE AND DENSITY*

DAMAGE DUE TO GALLOPING

MANY GALLOPING EVENTS CAUSE NO DAMAGE, BUT SEVERE AND PROLONGED GALLOPING APPLIES MANY REPETITIONS OF HIGH LOADS WHICH MUST BE COMPARED TO THE FATIGUE STRENGTH OF THE STRUCTURES AND COMPONENTS

EFFECTS OF MODEST GALLOPING:

- *FLASHOVERS BETWEEN VERTICALLY ALIGNED PHASES*
- *CIRCUIT OUTAGES AND*
- *BURNS OF CONDUCTORS*
- *DAMAGE TO BREAKERS IF THE CIRCUIT IS NOT ISOLATED*

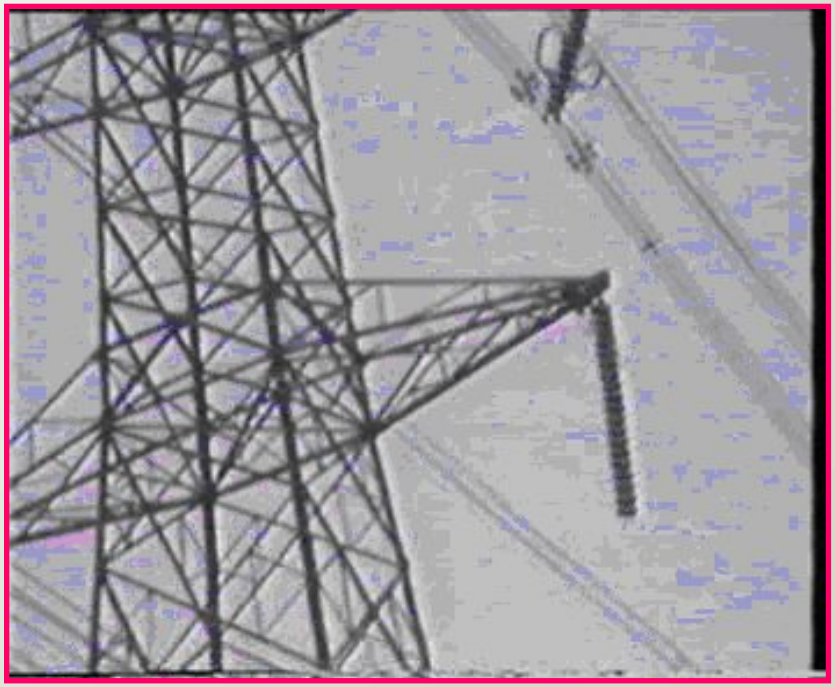


CONDUCTOR BURNS DUE TO GALLOPING

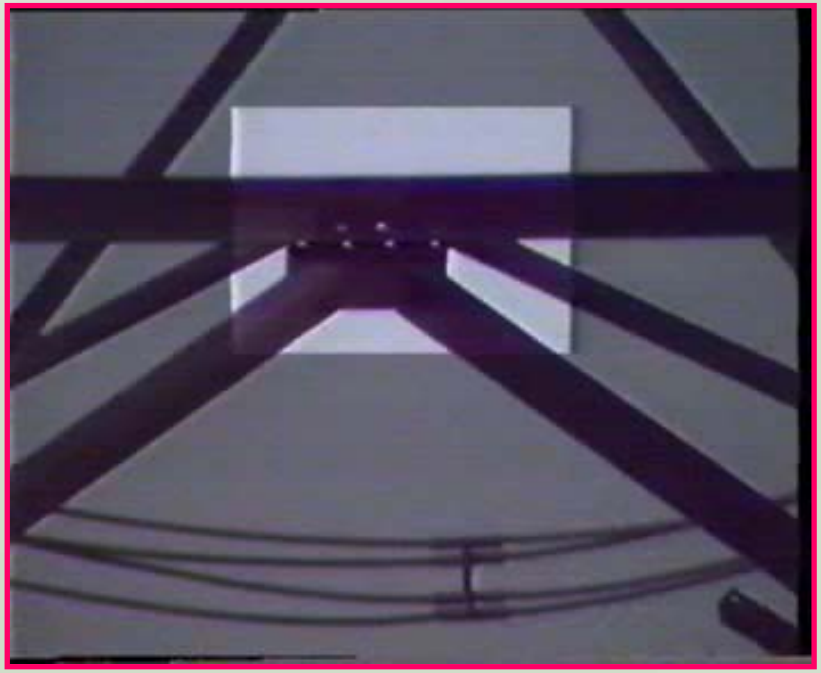
DAMAGE DUE TO GALLOPING

EFFECTS OF MODEST GALLOPING:

- *LOOSENED BOLTS*
- *SEPARATED INSULATOR STRINGS*



INSULATOR STRING SEPARATED DURING GALLOPING



TOWER GUSSET PLATE WITH ALL BOLTS FATIGUED DUE TO DYNAMIC LOADS ON A STRAIN TOWER DURING GALLOPING

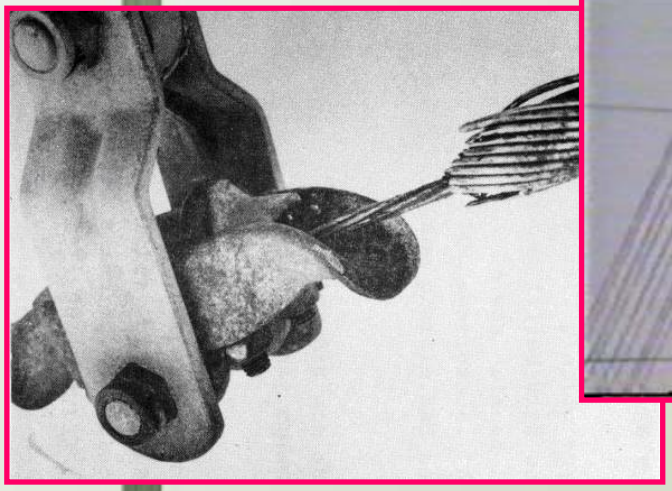
DAMAGE DUE TO GALLOPING

EFFECTS OF MODEST GALLOPING:

- *BROKEN HARDWARE*
- *FATIGUED CONDUCTOR STRANDS*

SPACER DAMPER BROKEN
DUE TO GALLOPING

JUMPER LOOPS OF QUAD BUNDLE
BROKEN DUE TO GALLOPING



CONDUCTOR FATIGUE
DAMAGE DUE TO GALLOPING

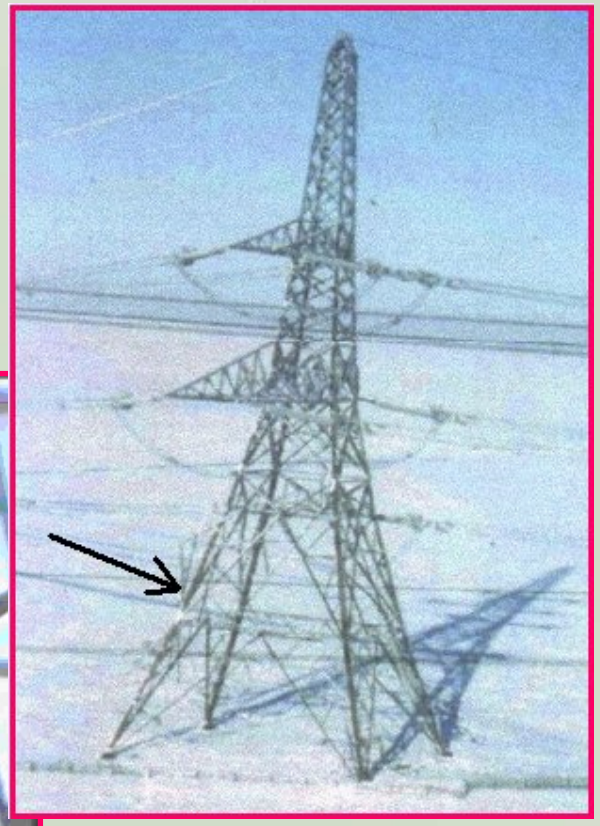
DAMAGE DUE TO GALLOPING

EFFECTS OF SEVERE AND PROLONGED GALLOPING:

- *FRACTURED TOWER MEMBERS*
- *COLLAPSED TOWER ARMS*
- *CASCADES OF LINE SECTIONS*

TOWER ARM BRACING MEMBERS BROKEN DUE TO GALLOPING

TOWER MAIN LEG BROKEN DURING GALLOPING



TOWER WITH LOWER ARM FAILED DUE TO GALLOPING

DYNAMIC LOADS DURING GALLOPING

MEASURED VERTICAL LOADS

SOURCE	CONDUCTOR	SPAN LENGTHS	STATIC LOAD kg	DYNAMIC LOAD kg	RATIO
ANJO et al. 1974	4 x 410 mm^2	312 m, 319 m	2100	3500	1.7
	4 x 950 mm^2	312 m, 319 m	4070	2500	0.6
KRISHNASAMY 1984	34 mm DIAM	459 m	1046	1990	1.9
	28 mm DIAM	418 m	677	810	1.2
	41 mm DIAM	216 m	626	1250	2.0
BROKENSHIRE 1979	2 x 30.4 mm DIAM	312 m, 308 m	1387	375	0.2
	2 x 30.4 mm DIAM	291 m, 242 m	1431	466	0.3
	2 x 30.4 mm DIAM	259 m, 251 m	1067	245	0.2
	2 x 36.2 mm DIAM	232 m, 256 m	1226	1364	1.1

DYNAMIC LOADS DURING GALLOPING

MEASURED HORIZONTAL LOADS

SOURCE	CONDUCTOR	SPAN LENGTHS	STATIC LOAD kg	DYNAMIC LOAD kg	RATIO
ANJO et al. 1974	4 x 410 mm^2	312 m, 319 m	6150	7400	1.2
	4 x 950 mm^2	312 m, 319 m	9300	7800	0.8
ESCARMELLE et al. 1997	2 X 620 mm^2	308 m	3600	4000	1.1
	2 X 620 mm^2	308 m	3600	7500	2.1
MORISHITA et al. 1984	4 X 410 mm^2	363 m, 247 m	2400	3120	1.3
	8 X 810 mm^2	230 m, 190 m	3000	3180	1.1
	6 X 410 mm^2	363 m, 247 m	2400	1920	0.8
	8 X 410 mm^2	353 m, 230 m, 350 m	2300	1470	0.6
	10 X 810 mm^2	230 m, 190 m	3000	1200	0.4
ELIASON 2002	28.1 mm DIAM	80 m	840	1870	2.2
	28.1 mm DIAM	80 m	800	2150	2.7
	28.1 mm DIAM	80 m	780	2160	2.8
	28.1 mm DIAM	80 m	800	1040	1.3

CONTROL OF GALLOPING

ICE MELTING

- *USED WHERE THE POWER TO CUSTOMERS CAN BE CUT OFF AND TAPS ARE PROVIDED TO CONNECT HIGHER THAN NORMAL CURRENT THROUGH THE LINES*

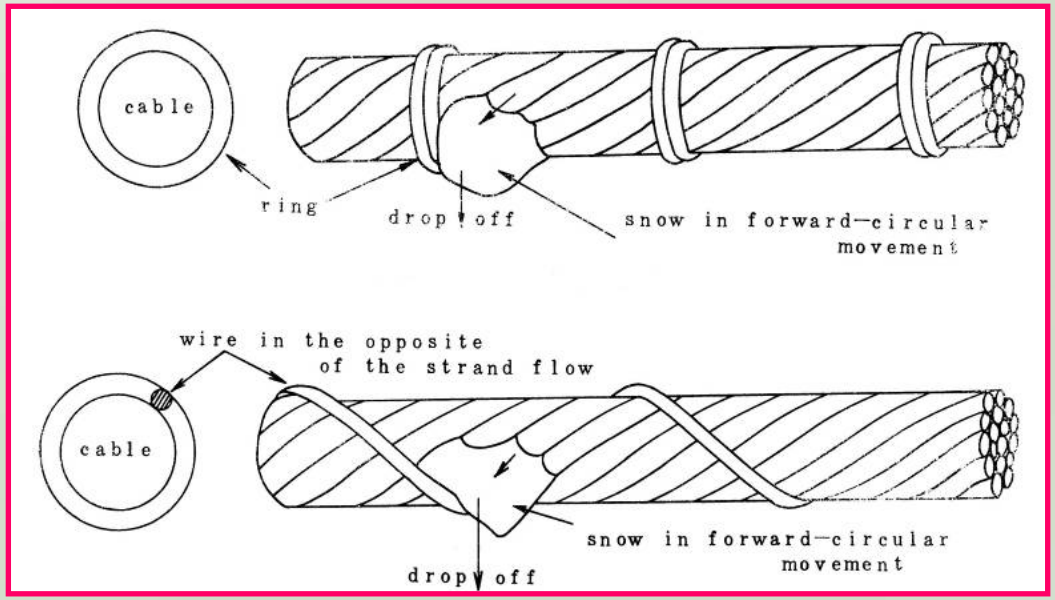
ICE REMOVAL

- *MECHANICAL ICE REMOVAL USING A ROLLER*

ICE PREVENTION

- *NO SUCCESSFUL ICE-PHOBIC COATING HAS BEEN DEVELOPED*

- *WET SNOW ACCRETIONS ARE BEING REDUCED THROUGH RINGS AND SPIRALLY WRAPPED WIRES IN JAPAN*

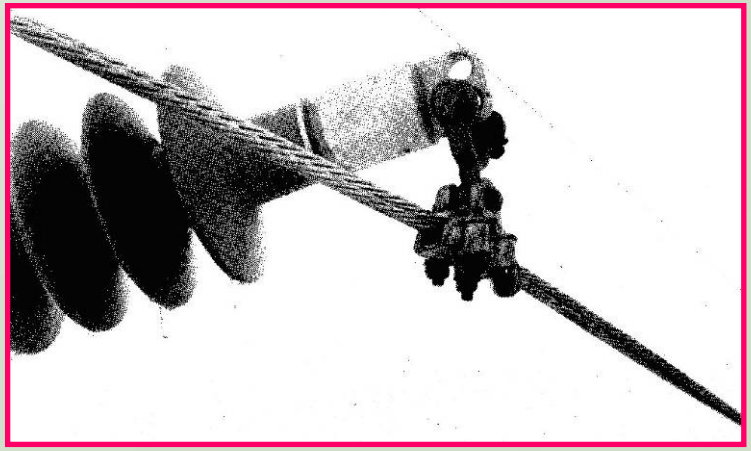


RINGS AND SPIRALS TO REMOVE WET SNOW

CONTROL OF GALLOPING

MODIFIED CONDUCTOR PROFILES

- *AERODYNAMICALLY MORE STABLE PROFILES SUCH AS THE TWISTED PAIR (T2 OR VR) AND ADDED PLASTIC SPIRALS SHOW REDUCTIONS IN GALLOPING OCCURRENCES AND SEVERITY*



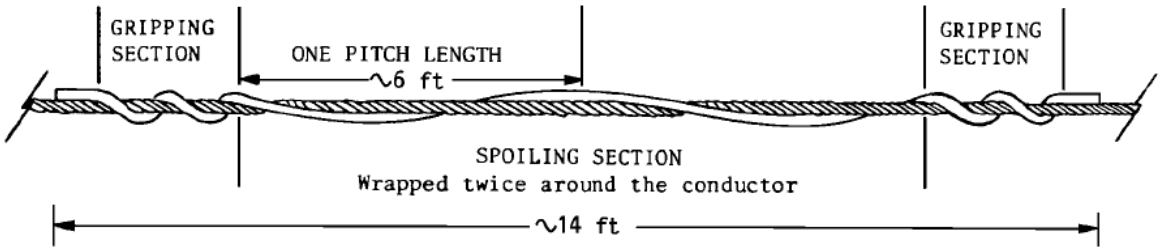
TWISTED PAIR CONDUCTOR

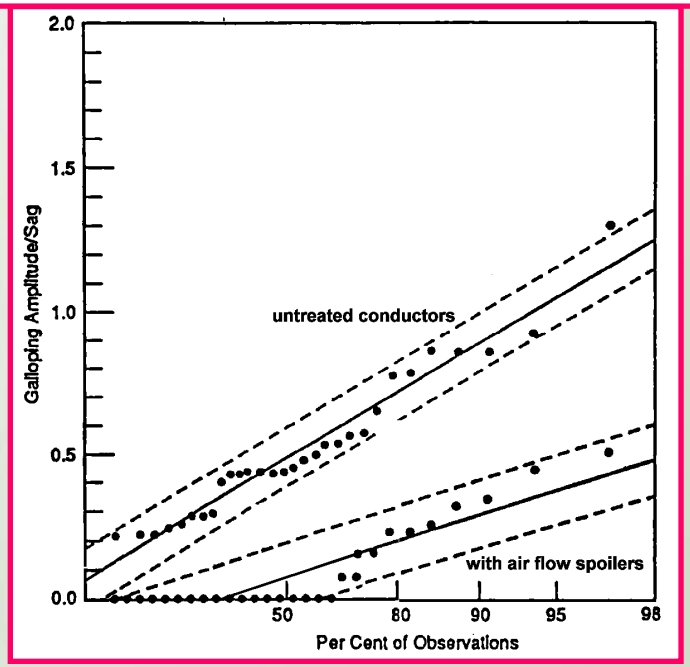
THE VARYING PROFILE ACROSS THE SPAN CREATES ALTERNATELY UPWARD AND DOWNWARD WIND FORCES WITH A NET REDUCTION IN TOTAL LIFT FORCE, UNLESS THE ICE LAYER THICKNESS OBSCURES THE SHAPE EFFECT

CONTROL OF GALLOPING

MODIFIED CONDUCTOR PROFILES

AIR FLOW SPOILERS FOR LOW VOLTAGE LINES

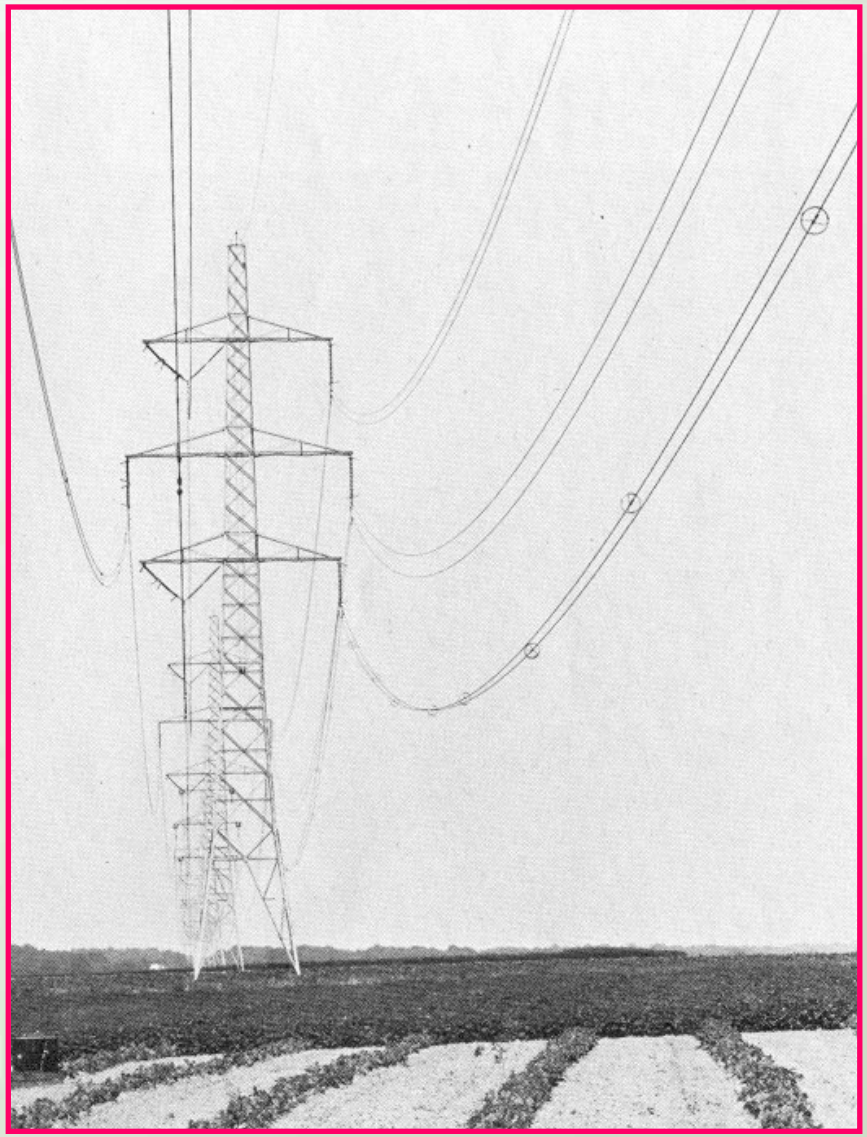




DATA FROM 31 FIELD OBSERVATIONS ON DISTRIBUTION LINES

- ***COMPARISON OF GALLOPING AMPLITUDES ON UNTREATED CONDUCTORS AND CONDUCTORS WITH AIR FLOW SPOILERS***
- ***AMPLITUDES SHOWN DIVIDED BY SAG TO NORMALIZE DATA FROM DIFFERENT SPAN LENGTHS***
- ***MAXIMUM GALLOPING AMPLITUDE REDUCED TO ABOUT 1/4 BY AIR FLOW SPOILERS***
- ***FORCES APPROX. EQUAL TO AMPLITUDE SQUARED***

CONTROL OF GALLOPING

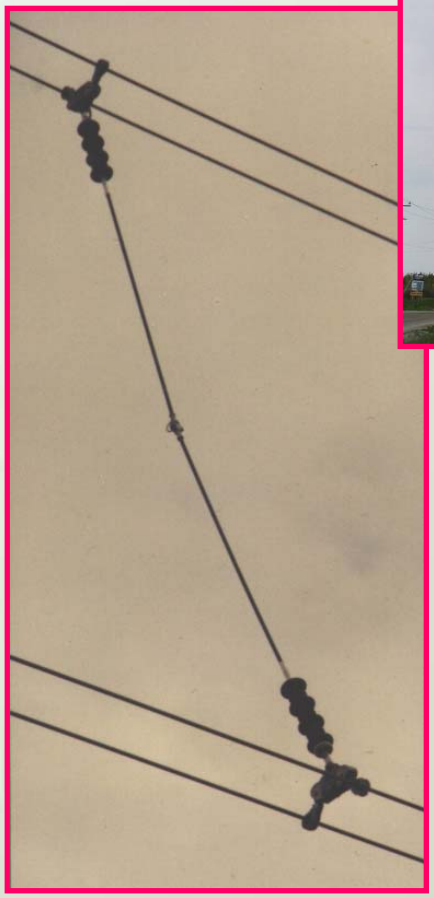


BUNDLE MODIFICATION

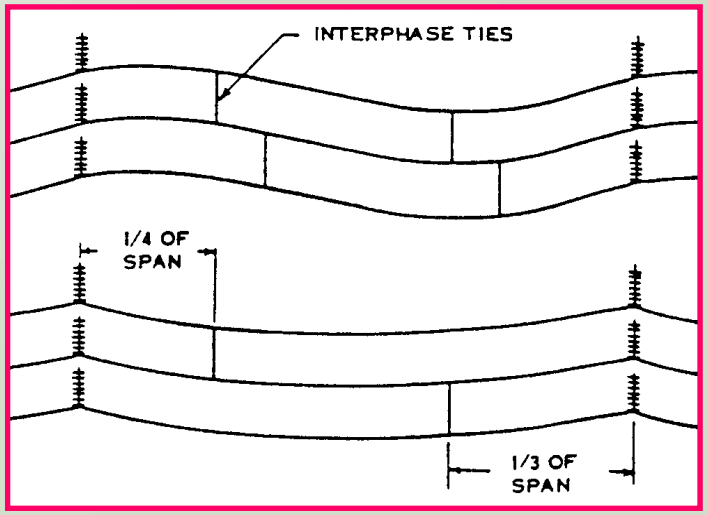
- *ROTATE BUNDLE TO VERTICAL*
- *SEPARATE SUBCONDUCTORS WITH HOOP SPACERS*
- *REDUCES TORSIONAL STIFFNESS OF THE SPAN AND ALLOWS WET SNOW TO FALL OFF AS THE CONDUCTORS ROLL UNDER THE ADDED WEIGHT*
- *NEED TO DISTINGUISH BETWEEN GLAZE ICE AND WET SNOW*

CONTROL OF GALLOPING

RIGID AND FLEXIBLE INTERPHASE SPACERS



- *POLYMERIC MATERIALS COMMONLY USED*
- *CORONA RINGS AT HIGH VOLTAGES*

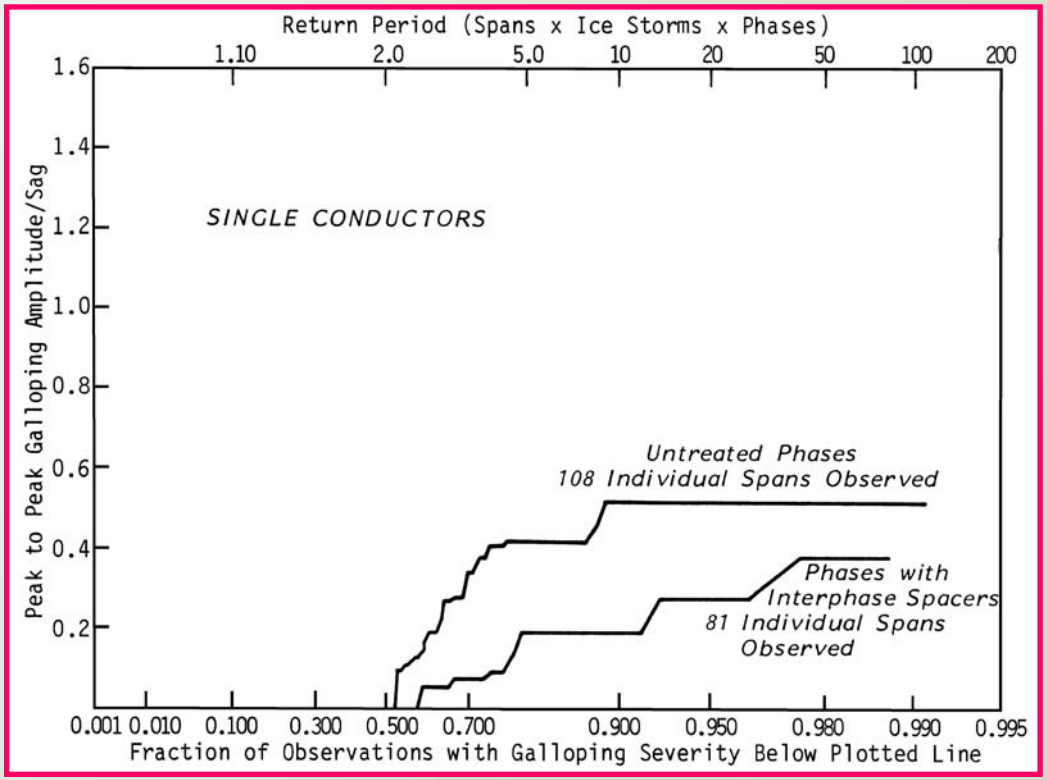


IN SPAN LOCATIONS

- *NEED TO AVOID MID-POINT*
- *TWO INTERPHASE SPACERS PER SPAN ON SHORT SPANS*
- *FOUR INTERPHASE SPACERS PER SPAN ON LONG SPANS*
- *POSSIBLE CLASHING WHEN TWO INTERPHASE SPACERS ARE USED*

CONTROL OF GALLOPING

INTERPHASE SPACERS



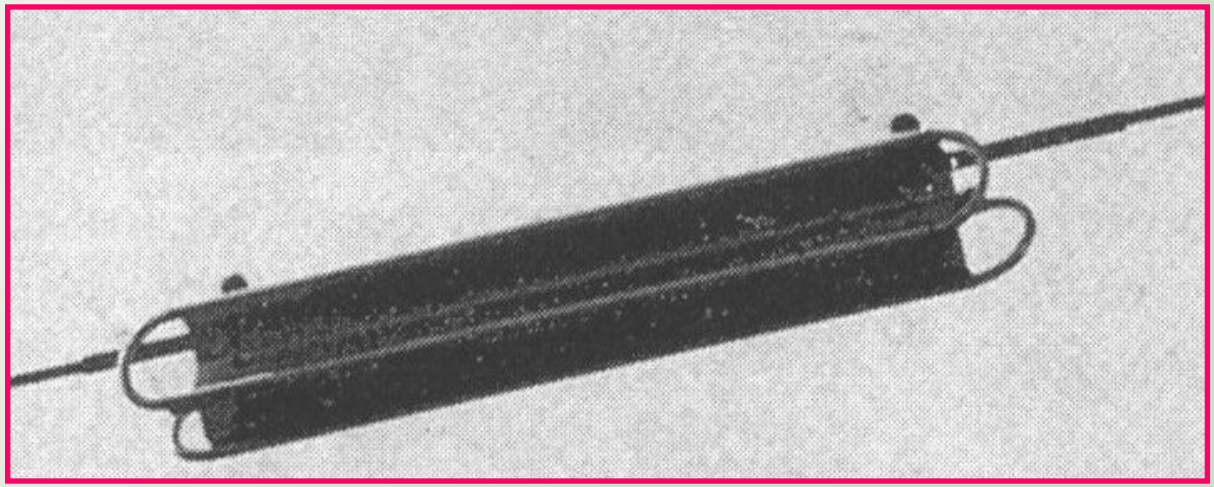
DATA FROM 10 FIELD OBSERVATIONS

- *COMPARISON OF GALLOPING AMPLITUDES ON UNTREATED CONDUCTORS AND CONDUCTORS WITH INTERPHASE SPACERS*
- *AMPLITUDES SHOWN DIVIDED BY SAG TO NORMALIZE DATA FROM DIFFERENT SPAN LENGTHS*
- *MAXIMUM GALLOPING AMPLITUDE REDUCED TO ~1/2*

VIDEO OF TWIN BUNDLE TEST LINE WITH “D” SECTION AIRFOILS AND INTERPHASE SPACERS (IREQ)

CONTROL OF GALLOPING

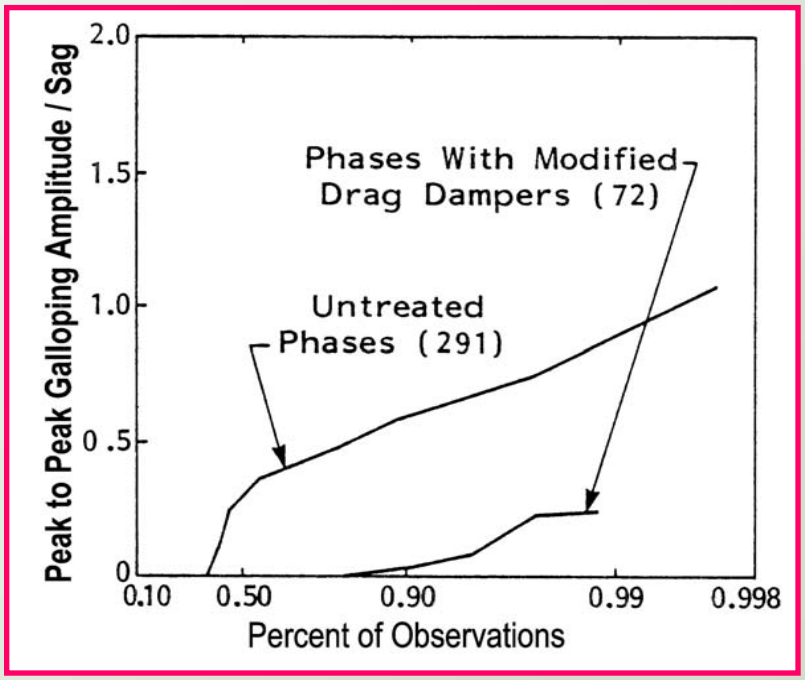
AERODYNAMIC DRAG DAMPER



- *GENERATES TORSIONAL MOTION TO SMOOTH THE ICE PROFILE*
- *VANES INCREASE BOTH AERODYNAMIC DRAG AND THE AERODYNAMIC DAMPING OF THE CONDUCTOR FOR GALLOPING CONTROL.*
- *MODIFIED DESIGN TESTED HAS A SLIGHT CHANGE OF ANGLE OF THE TWO CONCAVE SURFACES TO OPTIMIZE THE AERODYNAMIC CHARACTERISTICS*
- *MODIFIED VERSION WAS INSTALLED WITH BOTH HEAVY (45 kg, 100 lb) AND LIGHT (14 kg, 30 lb) DESIGNS IN EACH SPAN*

CONTROL OF GALLOPING

AERODYNAMIC DRAG DAMPER



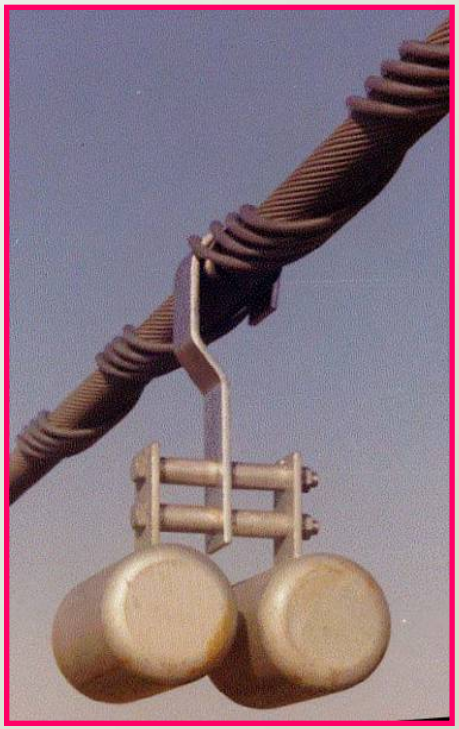
DATA FROM 8 FIELD OBSERVATIONS ON SINGLE CONDUCTORS

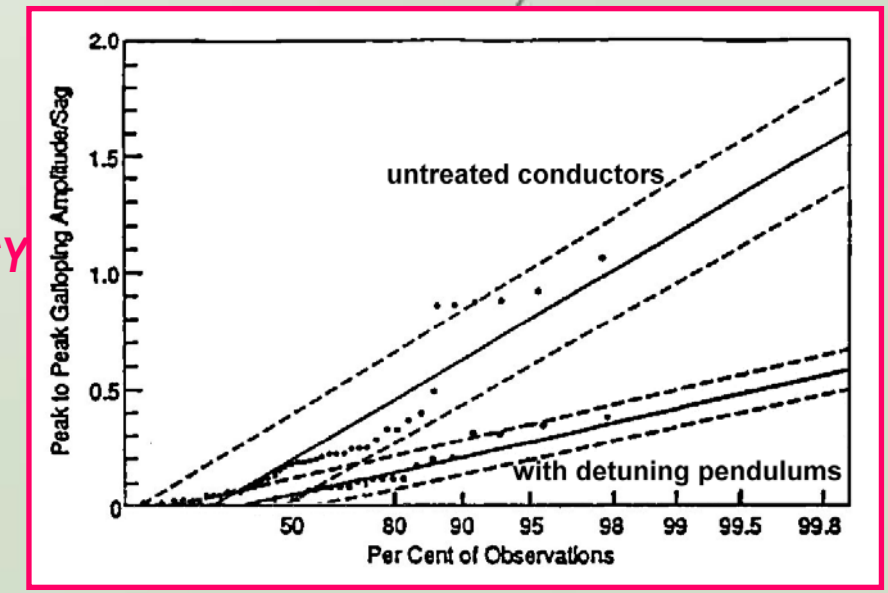
- *COMPARISON OF GALLOPING AMPLITUDES ON UNTREATED CONDUCTORS AND CONDUCTORS WITH MODIFIED DRAG DAMPERS*
- *AMPLITUDES SHOWN DIVIDED BY SAG TO NORMALIZE DATA FROM DIFFERENT SPAN LENGTHS*
- *MAXIMUM GALLOPING AMPLITUDE REDUCED TO ~1/3*

CONTROL OF GALLOPING

TORSIONAL DEVICES

- *DETUNING PENDULUM FOR SINGLE CONDUCTORS*
- *THREE OR FOUR PER SPAN*
- *ARM LENGTH CONTROLS FREQUENCY*
- *WEIGHT CONTROLS AMOUNT OF ICE*





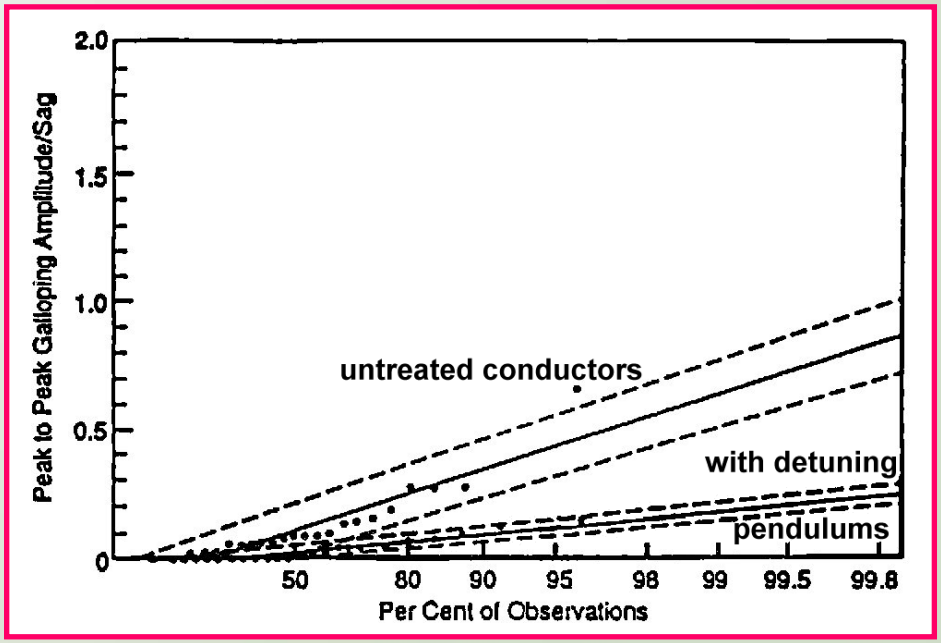
DATA FROM 43 FIELD OBSERVATIONS ON SINGLE CONDUCTORS (25 – 50 mm DIAM, 120 – 480 m SPANS)

- *COMPARISON OF GALLOPING AMPLITUDES ON UNTREATED CONDUCTORS AND CONDUCTORS WITH DETUNING PENDULUMS*
- *AMPLITUDES SHOWN DIVIDED BY SAG TO NORMALIZE DATA FROM DIFFERENT SPAN LENGTHS*
- *MAXIMUM GALLOPING AMPLITUDE REDUCED TO ~1/3*

CONTROL OF GALLOPING

TORSIONAL DEVICES

- *DETUNING PENDULUMS FOR TWIN BUNDLES*
- *THREE OR FOUR PER SPAN (AT 1/5, 1/3, 7/12, 3/4 POINTS)*
- *UNITS MOUNTED ON A RIGID SPACER*
- *PREFORMED ROD AND ELASTOMER LINING ATTACHMENTS TO REDUCE LOCAL STRESSES IN CONDUCTOR*



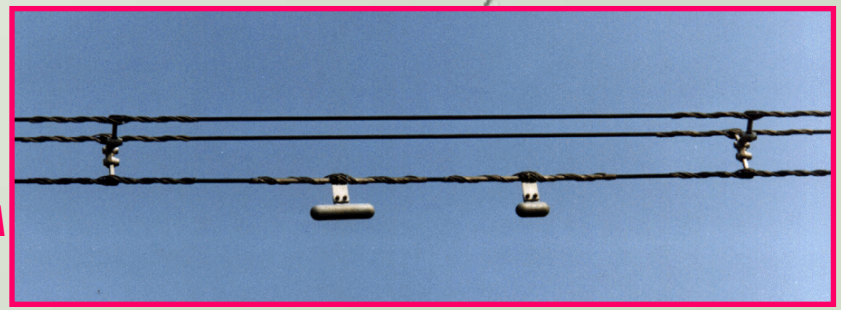
DATA FROM 24 FIELD OBSERVATIONS ON TWIN BUNDLES

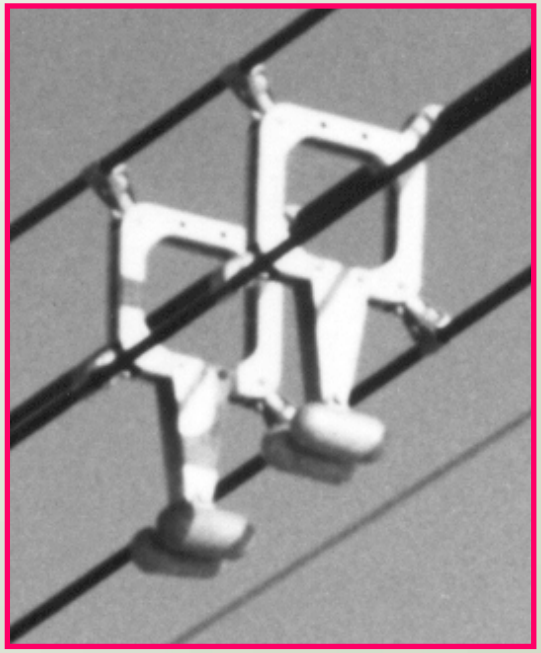
- *MAXIMUM GALLOPING AMPLITUDE REDUCED TO ~1/4*

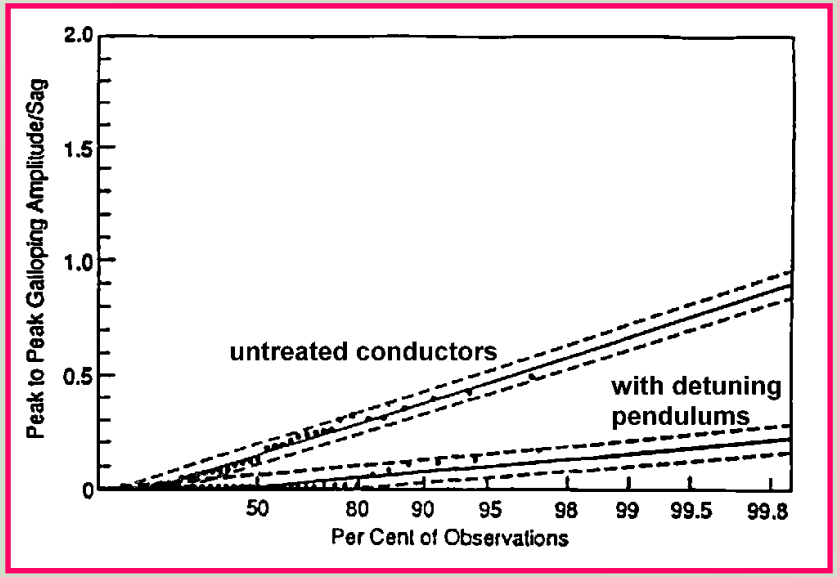
CONTROL OF GALLOPING

TORSIONAL DEVICES

- *DETUNING PENDULUMS FOR TRIPLE AND QUAD BUNDLES*
- *UNITS MOUNTED ON A SPACER DAMPER OR ON LOWER SUBCONDUCTOR W ITH EXTRA SPACERS TO MAINTAIN BUNDLE GEOMETRY*
- *ARM LENGTH LIMITED BY CORONA PERFORMANCE*



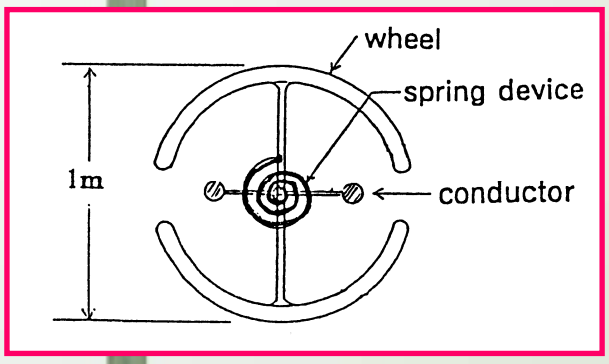


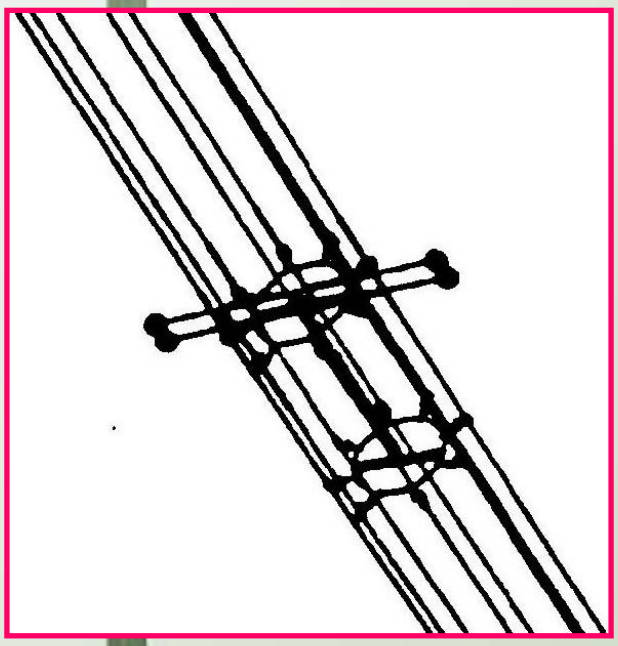


DATA FROM 32 FIELD OBSERVATIONS ON QUAD BUNDLES

- *MAXIMUM GALLOPING AMPLITUDE REDUCED TO ~1/4*

CONTROL OF GALLOPING





TORSIONAL DEVICES WITH DAMPING

- *TCD (Japan)*
- *TORSIONAL TUNER AND DAMPER (GCD, JAPAN)*
- *TORSIONAL DAMPER AND DETUNER (TDD, BELGIUM)*

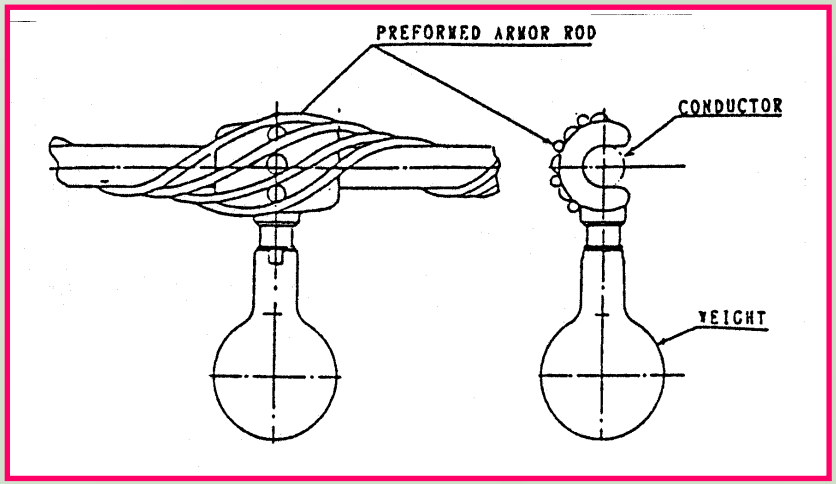
- *USUALLY TWO UNITS PER SPAN - DESIGNED TO MATCH SINGLE LOOP AND TWO LOOP GALLOPING FREQUENCIES*

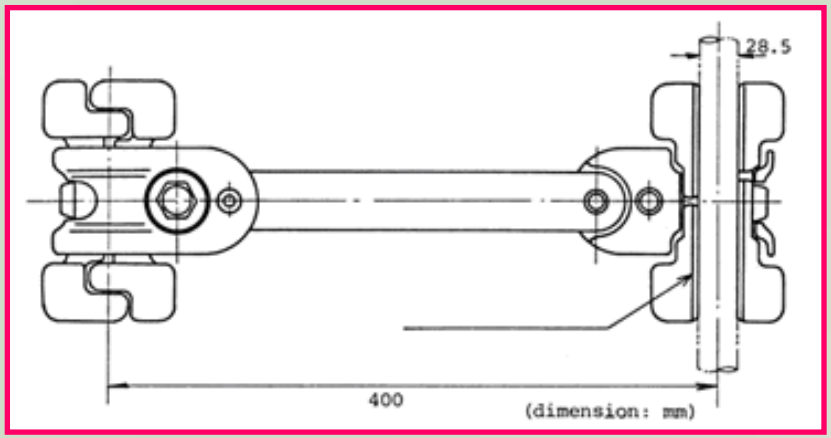
- *ALL TORSIONAL DEVICES ARE DESIGNED SPECIFICALLY FOR THE CONDUCTOR SIZE, SPAN LENGTH AND TENSION OF THE PARTICULAR SPANS TO WHICH THEY ARE ATTACHED*

CONTROL OF GALLOPING

ECCENTRIC WEIGHTS (GCD) AND ROTATING CLAMP SPACERS (JAPAN)

- *GALLOPING IS REDUCED WHEN THE ICE PROFILE IS SMOOTH AND LESS ECCENTRIC*
- *DEVICES ENCOURAGE CONDUCTOR OSCILLATION DURING ICE STORMS*
- *USED FOR WET SNOW EXPOSURE*
- *THE ECCENTRIC WEIGHTS ARE ABOUT 20 KG, AND ARE MOUNTED HORIZONTALLY IN ALTERNATING DIRECTIONS ON THE SUBCONDUCTORS*
- *SYSTEM APPLIED TO SINGLE CONDUCTORS AND TWIN AND QUAD BUNDLES*

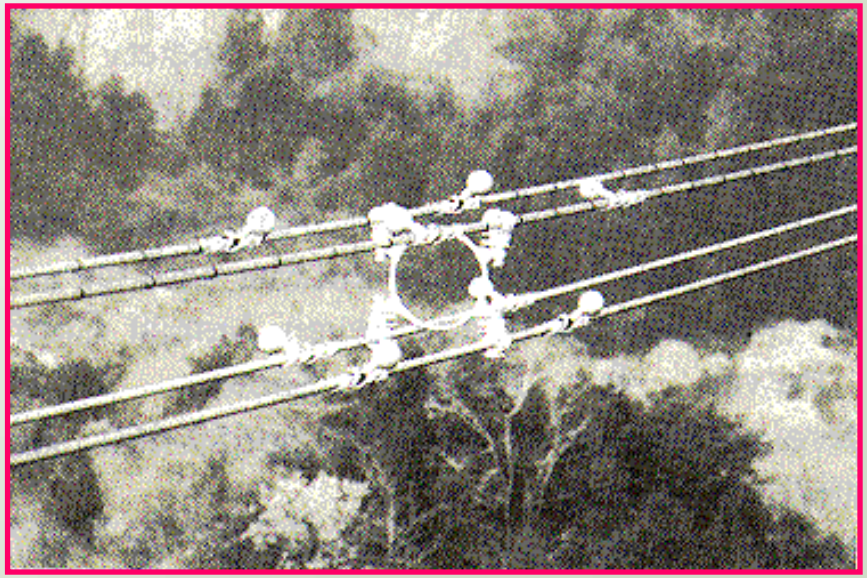


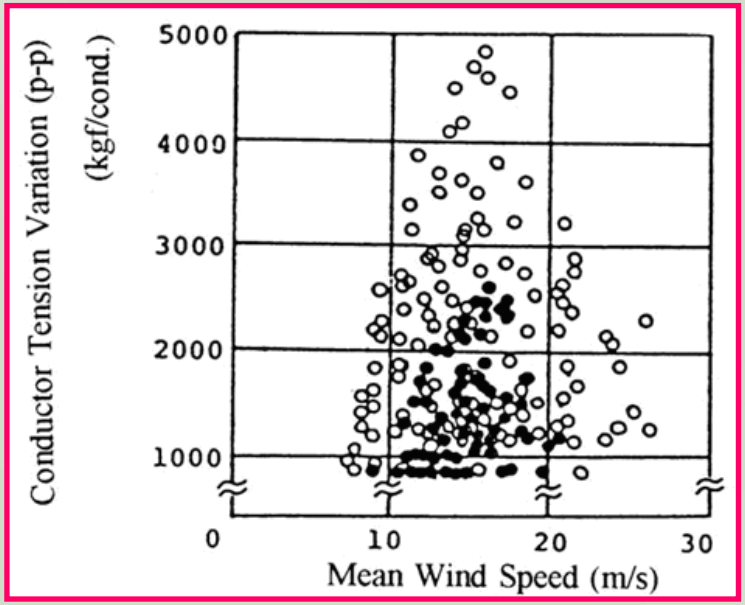


CONTROL OF GALLOPING

ECCENTRIC WEIGHTS (GCD) AND ROTATING CLAMP SPACERS (JAPAN)

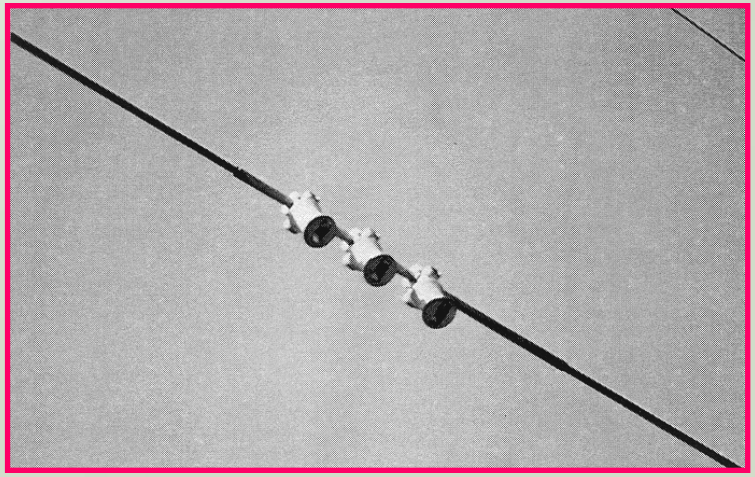
- *FIELD TRIALS SHOW REDUCED TENSIONS WITH GCD*
- *SYSTEM APPLIED TO SINGLE CONDUCTORS AND TWIN AND QUAD BUNDLES*





CONTROL OF GALLOPING

AR TWISTER (USA)



- *AR TWISTER IS DESIGNED TO CREATE A SMOOTH ICE PROFILE ON SINGLE CONDUCTORS*
- *THIS DEVICE IS A WEIGHT ATTACHED RIGIDLY TO THE CONDUCTOR BY A STANDARD CONDUCTOR CLAMP*
- *THE INDIVIDUAL WEIGHTS ARE ABOUT 3.6 KG (8 LB)*
- *THEY ARE INSTALLED VERTICALLY ABOVE THE CONDUCTOR AT MID-SPAN, AND THE TOTAL WEIGHT AND NUMBER OF DEVICES IS CHOSEN TO ROTATE THE CONDUCTOR BETWEEN 90 AND 140 DEGREES*
- *DURING GALLOPING THE ROTATIONAL OSCILLATIONS ARE ENHANCED, AND THE ICE DEPOSIT IS SMOOTHER AND THINNER*
- *THE AERODYNAMIC LIFT IS THEREBY REDUCED AND GALLOPING IS LESS LIKELY TO OCCUR.*

CONTROL OF GALLOPING

SUMMARY OF GALLOPING CONTROL DEVICES (1/3)

DEVICE NAME	APPL'N	WEATHER CONDITION		LINE CONSTRUCTION			COMMENTS
		GLAZE	WET SNOW	DIST'N	SINGLE TRANS'N	BUNDLE	
RIGID AND FLEXIBLE INTERPHASE SPACERS	WIDELY USED	YES	YES		YES	YES	PREVENTS FLASHOVERS, NOT GALLOPING MOTIONS
AIR FLOW SPOILER	WIDELY USED	YES		YES	YES	YES	COVERS 25% OF SPAN LIMITED BY VOLTAGE EXTENSIVE FIELD EVALUATION
ECCENTRIC WEIGHTS & ROTATING CLAMP SPACERS	USED IN JAPAN		YES		YES	YES	THREE PER SINGLE SPAN ONE PER SPACER PER SUB-CONDUCTOR

CONTROL OF GALLOPING

SUMMARY OF GALLOPING CONTROL DEVICES (2/3)

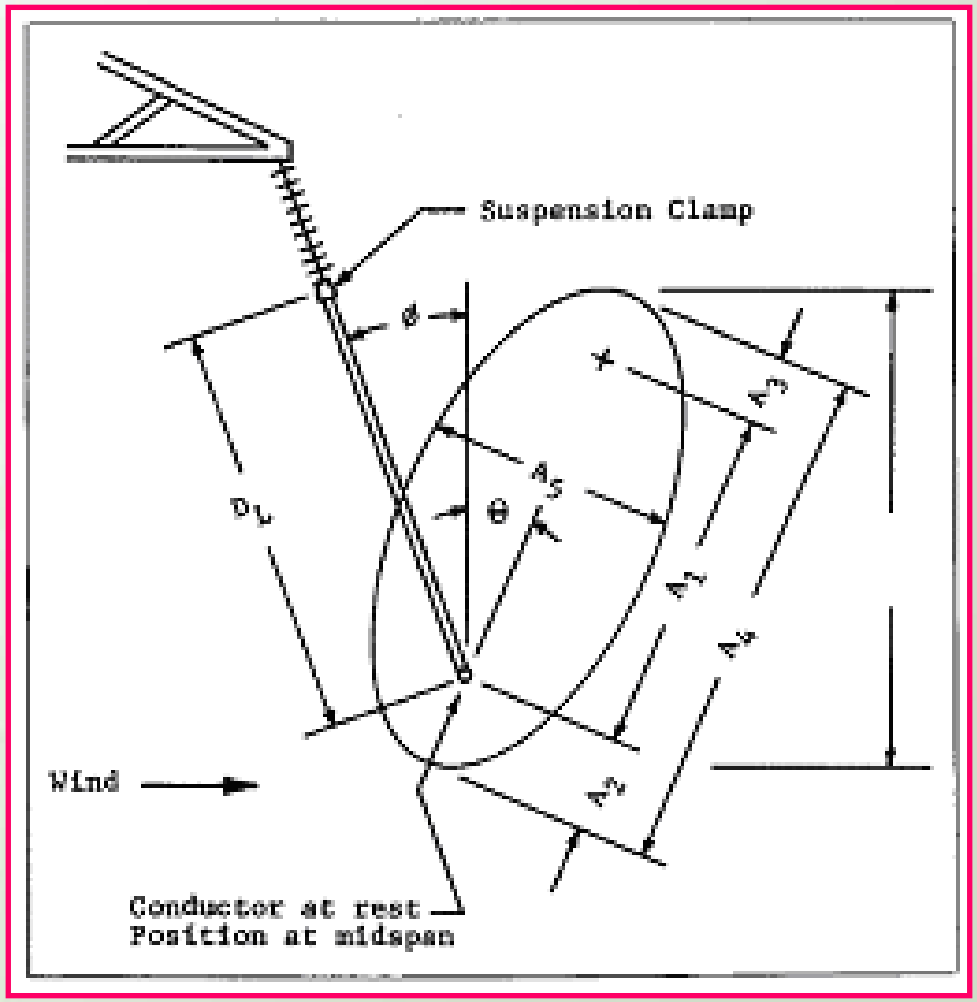
DEVICE NAME	APPL'N	WEATHER CONDITION		LINE CONSTRUCTION			COMMENTS
		GLAZE	WET SNOW	DIST'N	SINGLE TRANS'N	BUNDLE	
AR TWISTER	USED IN USA	YES			YES	YES	TWO PER SPAN
AR WINDAMPER	USED IN USA	YES			YES	YES	TWO PER SPAN
TORSIONAL CONTROL DEVICE (TCD)	USED IN JAPAN		YES			YES	TWO PER SPAN

CONTROL OF GALLOPING

SUMMARY OF GALLOPING CONTROL DEVICES (3/3)

DEVICE NAME	APPL'N	WEATHER CONDITION		LINE CONSTRUCTION			COMMENTS
		GLAZE	WET SNOW	DIST'N	SINGLE TRANS'N	BUNDLE	
GALLOPING CONTROL DEVICE (GCD)	USED IN JAPAN		YES			YES	TWO PER SPAN
DETUNING PENDULUM	WIDELY USED	YES		YES	YES	YES	3 OR 4 PER SPAN. USES ARMOR RODS IF TENSION IS HIGH. MOST EXTENSIVE FIELD EVALUATIONS
TORSIONAL DAMPER AND DETUNER (TDD)	EXPER-IMENTAL	YES				YES	2 OR 3 PER SPAN

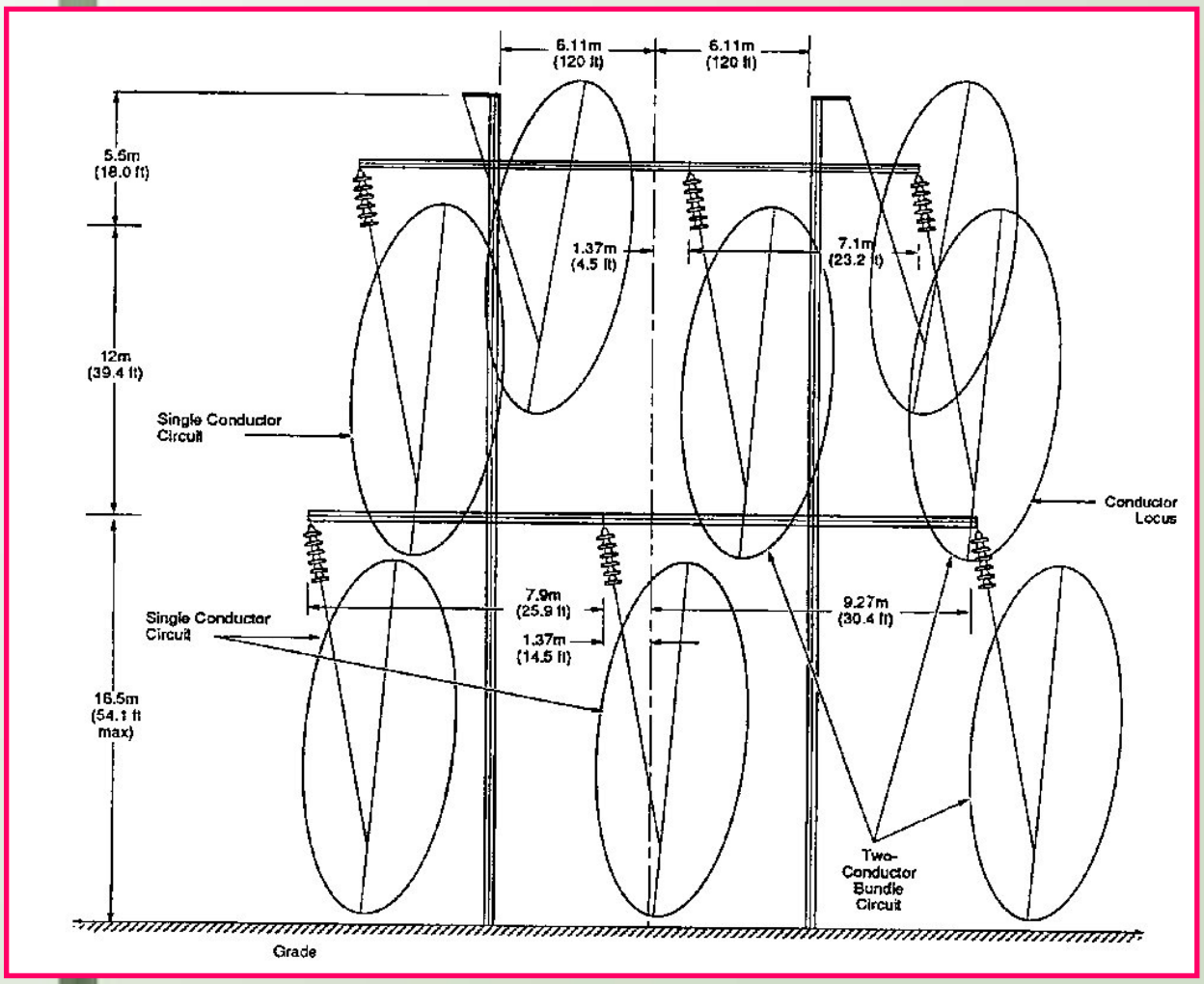
DESIGN AGAINST GALLOPING



RURAL ELECTRIFICATION ADMINISTRATION (REA) GUIDE

- *COMMON DESIGN METHOD IS ELLIPTICAL CLEARANCE ENVELOPE - BASED ON 1930S TECHNOLOGY*
- *ANGLE OF ELLIPSE RELATED TO SWING ANGLE OF CONDUCTOR*
- *ASSUMES MOTIONS LIMITED TO ~1.3 x SAG ON SPANS SHORTER THAN 230 m*
- *VERTICAL HEIGHT BASED ON MULTIPLE LOOP GALLOPING ON SPANS LONGER THAN 230m*

DESIGN AGAINST GALLOPING



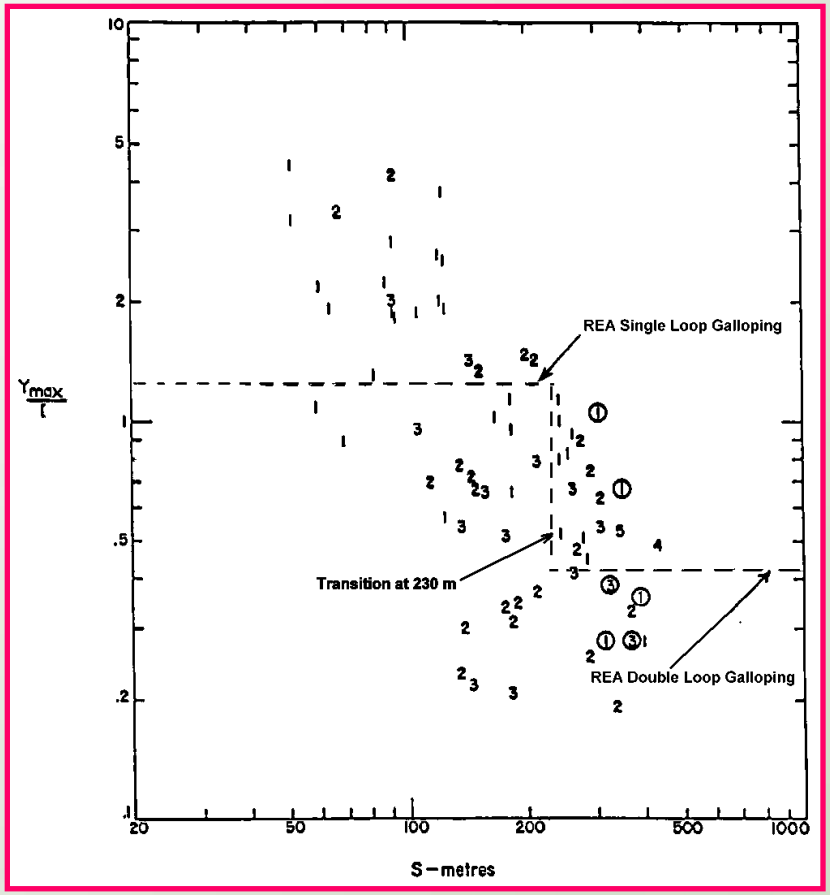
GALLOPING CLEARANCE ELLIPSES FOR A STRUCTURE

- *STRUCTURE HAS TWO CIRCUITS AND TWO OVERHEAD GROUND WIRES*
- *ELLIPSE OVERLAPS SHOW FLASHOVER POINTS DURING GALLOPING*
- *AIR GAP REQUIRED BETWEEN ELLIPSES BASED ON VOLTAGE OF LINE*

PHASE TO PHASE AND PHASE TO GROUND CLEARANCES REQUIRED BETWEEN GALLOPING CLEARANCE ELLIPSES

Voltage	115 kV	138 kV	230 kV	345 kV	500 kV
Phase-Phase	0.46 m (1.5 ft)	0.46 m (1.5 ft)	0.76 m (2.5 ft)	1.07 m (3.5 ft)	1.83 m (6.0 ft)
Phase-Ground	0.30 m (1.0 ft)	0.30 m (1.0 ft)	0.61 m (2.0 ft)	0.76 m (2.5 ft)	1.22 m (4.0 ft)

DESIGN AGAINST GALLOPING

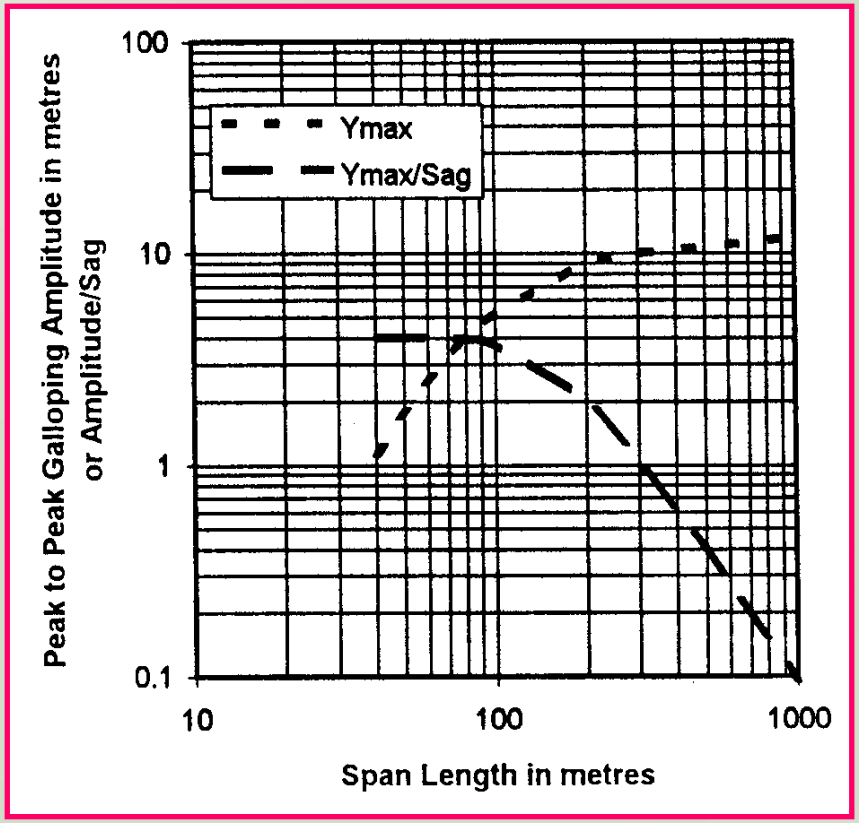


PEAK TO PEAK GALLOPING AMPLITUDE / SAG vs SPAN LENGTH FROM FIELD DATA AND CORRESPONDING REA GUIDE

- *FIELD DATA ON GALLOPING SHOW DEFICIENCIES IN ASSUMED GALLOPING MOTIONS*
- *DIFFERENCE BETWEEN GALLOPING DUE TO GLAZE ICE AND WET SNOW NEEDS TO BE RECOGNIZED*
- *DYNAMIC LOADS DUE TO GALLOPING ARE NOT EXPLICITLY INCLUDED*
- *DESIGN APPROACH NEEDS UPDATING BASED ON PRESENT KNOWLEDGE*

DESIGN AGAINST GALLOPING

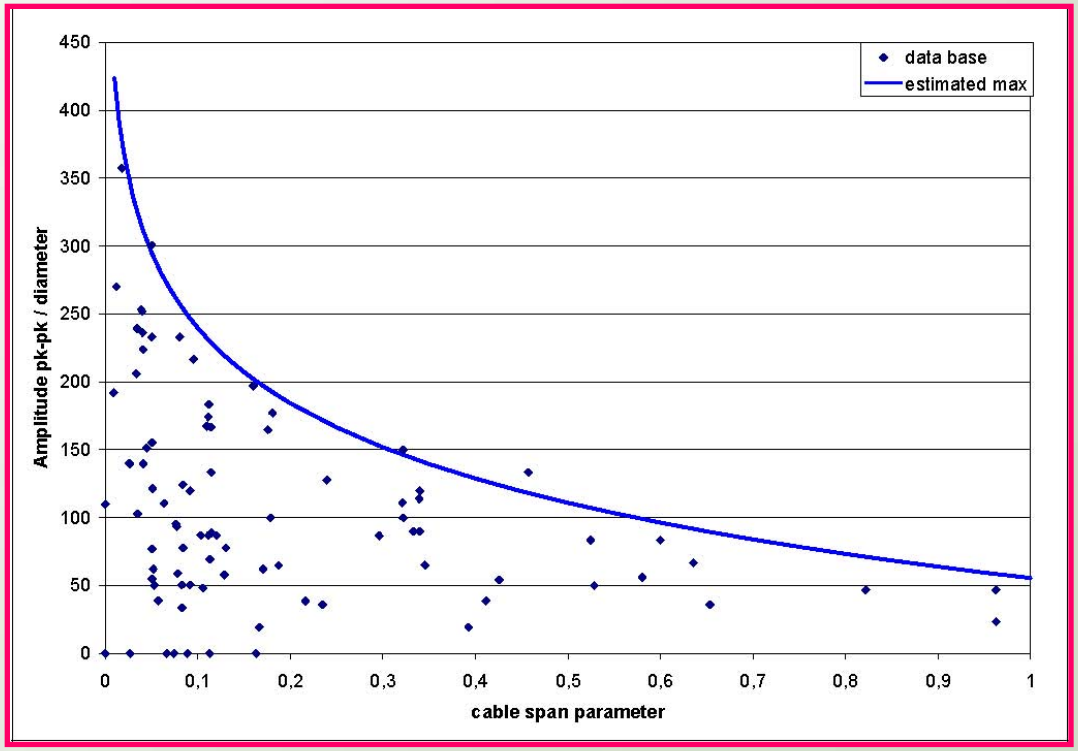
- *BASED ON ANALYSIS OF FIELD DATA FROM ALL GALLOPING OBSERVATIONS*
- *DATA FROM SINGLE CONDUCTOR SITES ONLY*
- *BUNDLE DATA IS FOR LONGER SPANS LENGTHS ONLY*
- *SIMILAR ENVELOPES OF MAXIMUM AMPLITUDE AND AMPLITUDE/SAG FOR BUNDLE CONDUCTORS*



MAXIMUM GALLOPING AMPLITUDE AND AMPLITUDE/SAG VERSUS SPAN LENGTH

- *ENVELOPES OF FIELD DATA*

DESIGN AGAINST GALLOPING



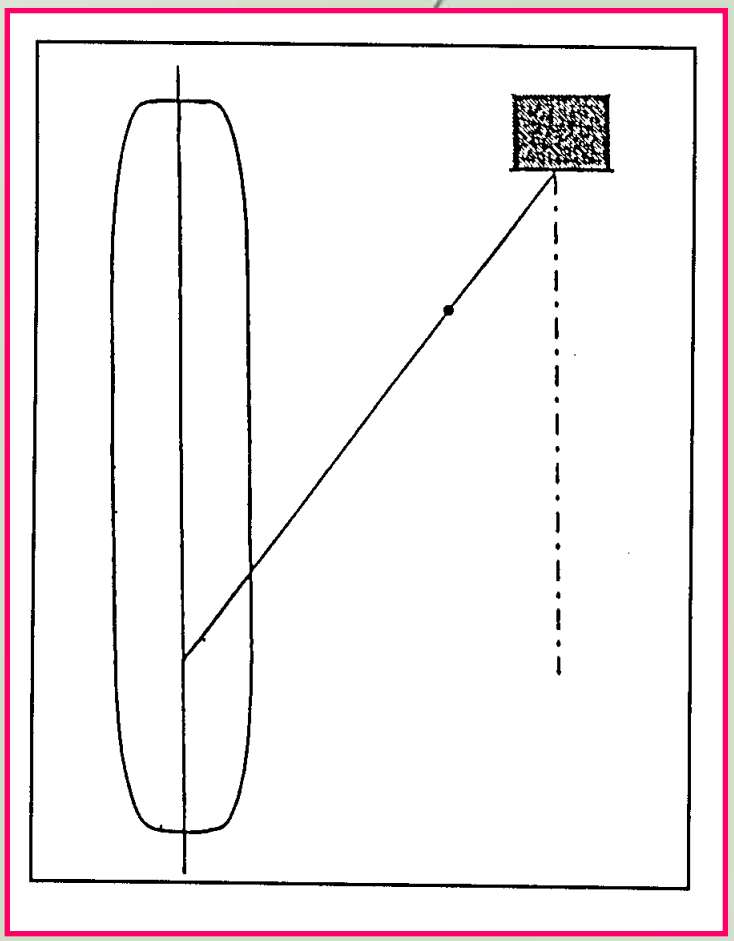
CABLE SPAN PARAMETER = 100 X DIAM / 8 X SAG

FITTED CURVE: A/D = 80 LN (8 X SAG / 50 X DIAM)

- *ALTERNATIVE CURVE OF MAXIMUM GALLOPING AMPLITUDES WITH BETTER FIT TO THE DATA*
- *AMPLITUDE/DIAMETER VS CABLE SPAN PARAMETER*
- *SAME CURVE FOR SINGLE AND BUNDLE CONDUCTORS*
- *DATA ARE FOR GLAZE ICE CONDITONS*
- *MORE DATA ARE NEEDED FOR GALLOPING DUE TO WET SNOW*

ALTERNATIVE GALLOPING ENVELOPE

- *BASED ON FRAME BY FRAME ANALYSIS OF 44 MOVIE FILMS OF GALLOPING FROM SINGLE AND TWIN, TRIPLE, AND QUAD BUNDLE LINES*
- *ALL GALLOPING EVENTS FILMED WERE DUE TO GLAZE ICE*
- *MOTIONS ARE ALMOST ENTIRELY VERTICAL*
- *WIDTH OF ENVELOPE IS 20 PERCENT OF HEIGHT*
- *UPWARD MOVEMENT IS 3 TIMES AS LARGE AS DOWNWARD MOVEMENT FROM STATIC POSITION*



ENVELOPE OF GALLOPING MOTIONS BASED ON FILM ANALYSIS

CONCLUSIONS (1 OF 2)

- *GALLOPING ON POWER LINES MAY INDUCE SERIOUS DAMAGE ON ALL PARTS*
- *OCCURRENCES ARE DIFFICULT TO PREDICT BECAUSE THEY DEPEND ON THE ICE SHAPE AND DENSITY, WIND SPEED AND DIRECTION, AND DYNAMIC STRUCTURAL PROPERTIES, SUCH AS NATURAL FREQUENCY AND STIFFNESS OF THE CONDUCTOR UNDER THE ICE AND WIND CONDITIONS*
- *GALLOPING IS A COMPLEX AEROELASTIC INSTABILITY*
- *CONTROLS FOR PREVENTING GALLOPING ARE MAKING PROGRESS*

CONCLUSIONS (2 OF 2)

- *THE TWO MECHANISMS OF GALLOPING NEED DIFFERENT MEANS OF PREVENTION*
- *DIFFERENT ICE AND WET SNOW CONDITIONS NEED DIFFERENT TREATMENT*
- *SINGLE AND BUNDLE CONDUCTORS NEED DIFFERENT TREATMENT*
- *DESIGN ELLIPSES CAN BE USED FOR CLEARANCES AND TOWER CAN BE DESIGNED TO RESIST THESE EXCEPTIONAL EVENTS*
- *NEW INFORMATION IS AVAILABLE TO UPDATE DESIGN CLEARANCES FOR SOME CONDITIONS*

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ATTACHMENT 2
TO HYDRO ONE NETWORKS INC. ARGUMENT-IN-CHIEF
DATED OCTOBER 22, 2018

Tower Head Design for Galloping Based on New CIGRÉ Criteria

David G. Havard
Havard Engineering Inc.
Canada

SUMMARY

CIGRÉ Technical Brochure 322 "State of the Art of Conductor Galloping", published in June 2007, summarized current knowledge of the technology, but falls short of providing guidance to the line designer on the application of the findings. This paper provides an example of a practical application of the results in that Technical Brochure.

The Technical Brochure covers the available field data on galloping of a wide range of overhead lines in both single and bundle configurations, with short and long spans, and for a range of conductor diameters. Examples of the damage due to galloping that are included are conductor burns and breakage, vibration damper messenger wire drooping and loss of weights due to fatigue, and wear of other hardware, as well as damage to tower members and tower arms. Field measurements show that the dynamic loads due to galloping are up to twice the vertical load and up to 2.9 times the longitudinal loads.

Many control device options are discussed in the Technical Brochure, and where field data are available, the effectiveness of each device is compared. Detailed analysis of films of galloping on actual lines led to a revision of the previous "ellipse" envelopes on which past designs of tower head clearance were based. The new envelope is more upright and narrower than the previous ellipse shapes.

This paper offers an example of the use of this new approach for a newly designed line in Canada. The results are shorter towers with shorter arms, and narrower rights of way. This represents significant savings in line cost. This line is in a region where galloping is an annual event. The position of the utility involved is to have interphase spacers as a backup alternative for those spans that are found to be seriously affected by galloping.

An analytical interpretation of the field data on which the new approach is based, allows refinement of the estimates of galloping amplitudes for different conductor sizes and tensions, on both single and bundle lines. Generally, larger conductors are predicted to reach higher galloping amplitudes in both single and bundle arrangements. Contrary to common belief, tension changes, on the other hand, show little influence on the galloping amplitude.

While most documented field data on galloping are from freezing rain events, there are some published data on wet snow and rime events and an example of the use of that data for design is also included. This paper presents a practical application of the new data on galloping behaviour, and could form the basis for an updated design guide for galloping prone line environments.

KEYWORDS

Bundle Conductors- Clearance- Conductors- Design- Dynamic Loads- Galloping- Ice- Overhead Lines-Towers-Wet Snow

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Background

Conductor galloping is an aerodynamic effect that produces very large amplitude, mainly vertical, motions of conductors when a modest to strong wind blows on ice or wet snow covered conductors. It can occur on single and bundle conductor transmission lines as well as on distribution lines and overhead ground wires. Galloping motions can cause damage such as: conductor burns and breakage, vibration damper messenger wire drooping and loss of weights due to fatigue, wear of insulators and other hardware, and fractured tower members and tower arms.

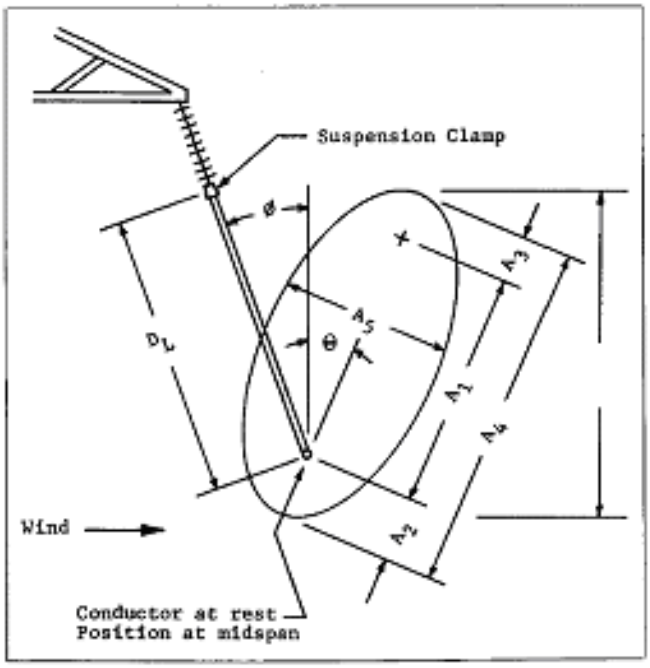

Figure 1 Schematic of classic galloping clearance ellipse [4]

Classic Design Practice

This paper applies the data included in the CIGRÉ Technical Brochure 322 "State of the Art of Conductor Galloping" [1], for use in tower design. Traditional design of tower heads to limit clashing during galloping have been based on studies by Davison [2], formalized in the REA Design guide [3] and variations of the approach have been summarized in the EPRI "Orange" book [4]. The methodology can be illustrated by Figure 1 which shows an envelope encompassing possible galloping motions circumscribing the mid point of the span of a galloping conductor. The conductor is shown at an angle due to the action of a wind force of 55 kPa (8 pfs) acting on the conductor carrying 12.7 mm (½ in) of radial ice. A typical practice is to assume the ellipse height will be 1.25 times the loaded sag. A number of utilities have assumed that two loop galloping will only occur at span lengths above 215 m (700ft), and for dead-end spans. For those longer spans the major ellipse axis is assumed to be 0.35 times the loaded sag.

Voltage	115 kV	138 kV	230 kV	345 kV	500 kV
Phase-phase	0.46 m (1.5 ft)	0.46 m (1.5 ft)	0.76 m (2.5 ft)	1.07 m (3.5 ft)	1.83 m (6.0 ft)
Phase - ground	0.30 m (1.0 ft)	0.30 m (1.0 ft)	0.61 m (2.0 ft)	0.76 m (2.5 ft)	1.22 m (4.0 ft)

Table 1 Phase to Phase and Phase to Ground Clearances Required between Galloping Clearance Envelopes [4]

To avoid flashovers, the ellipses should be separated by air gaps according to the voltage of the line. Table 1 gives the required gaps for phase to phase and phase to ground conductors [4].

Field Data

Over the years many electrical utility groups have engaged in field programs to study galloping and this has led to an extensive database on galloping motions. That data base documented details of some 140 galloping events, mainly on single conductor lines. Some analyses of these results have been published by EPRI [4]. When the field data are compared to the size of ellipses proposed based on traditional design methods, major differences become apparent. Figure 2 shows the field data from an early field study, with traditional design practice [3], superimposed. The field data show that the practice is non-conservative for all spans lengths. Also the assumption of only multiple loop galloping on long spans is belied by the observed numbers of loops as indicated by the numbers assigned to each point in Figure 2.

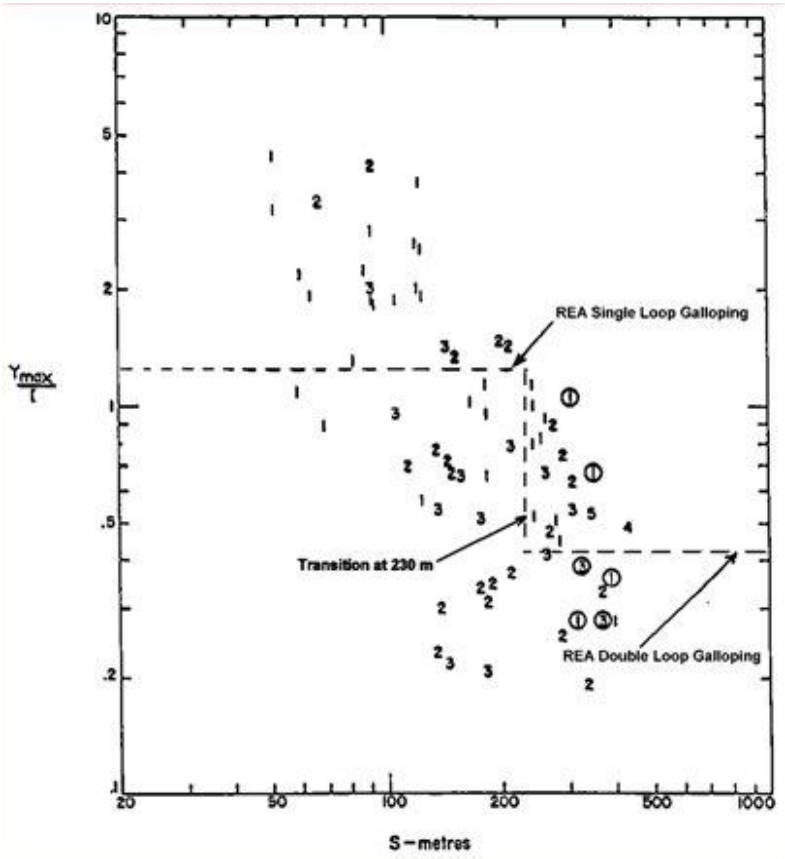

Figure 2 Peak - peak galloping amplitude vs. span length from field data including traditional design practice. Numbers indicate number of loops [4]

The data obtained in these field studies were used to develop empirical relationships between maximum galloping amplitude and span properties. Figure 3 presents the simple relationships describing peak to peak galloping amplitude versus span length, and peak to peak galloping amplitude divided by sag versus span length, for single conductors derived from that set of data. That figure is based on data from 95 field observations of galloping on single conductors. The maximum motion observed was 12 m (40 feet) peak to peak.

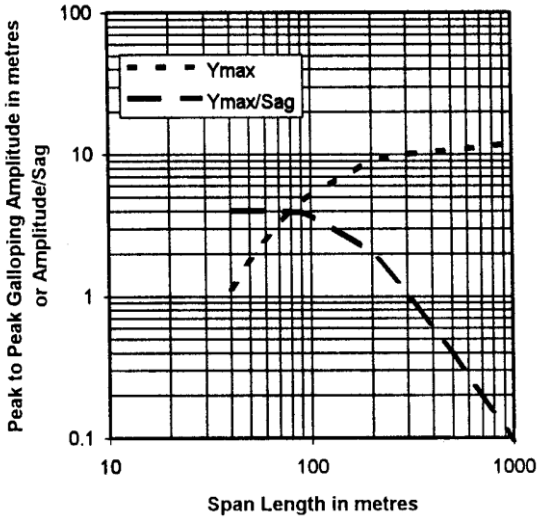

Figure 3 Peak - peak galloping amplitude and peak - peak galloping amplitude divided by sag, as functions of span length for single conductors [5]

The galloping was caused by freezing rain for most of the cases used. The equivalent observations for bundle conductors are from a more limited range of span lengths, and 56 observations, but the maximum observed values conform to the envelope around the single conductor data. The database for bundle conductors comprised mainly twin and quad bundles with only limited observations from triple bundles.

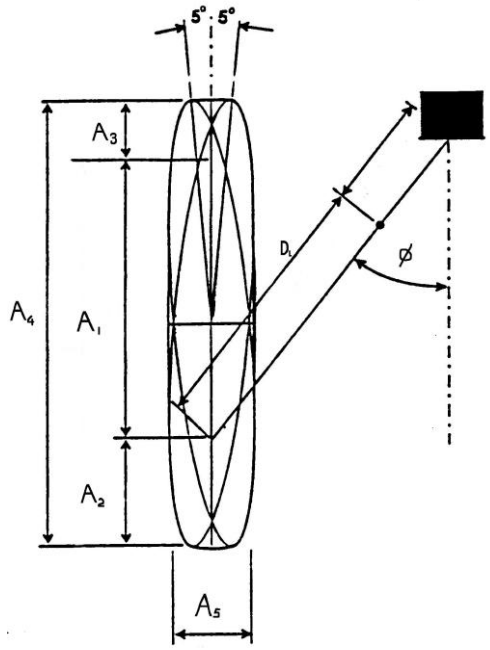

Figure 4 Proposed galloping clearance envelopes [5]

Modified Clearance Envelope

These field trials also produced a substantial archive of films and videotapes of galloping events. The films included motions of single, twin, triple and quad bundle lines. The clearest of these films were selected for careful analysis of the motions. The analysis of the films leads to a possible new clearance envelope replacing the traditional elliptical envelope. This is shown in Figure 4. The envelope is constructed from two narrow ellipses inclined at 5 degrees each side of vertical. The ellipse height is in accordance with the field data in Figure 3, and the width to height ratio is 0.2. The ellipse is positioned such that the quarter point is at the static position of the iced conductor. The profile is completed by tangential straight lines around the two ellipses.

Application Example

This approach to design for galloping clearances has been adopted by a major Canadian provincial utility and found to offer valuable savings in tower costs. Figure 5 shows comparable double circuit 230 kV running angle towers designed by the traditional method and using the new envelope. The tower based on traditional design is 53.08 m (174 ft) high and 20 m (65.6 ft) wide. The tower based on the new envelope is 43.33 m (142 ft) high and 19 m (62.3 ft) wide. The new towers are more slender and shorter, less costly and require less right of way. Other galloping effects, such as dynamic loads are not changed by this design and the utility involved will apply galloping control devices as necessary.

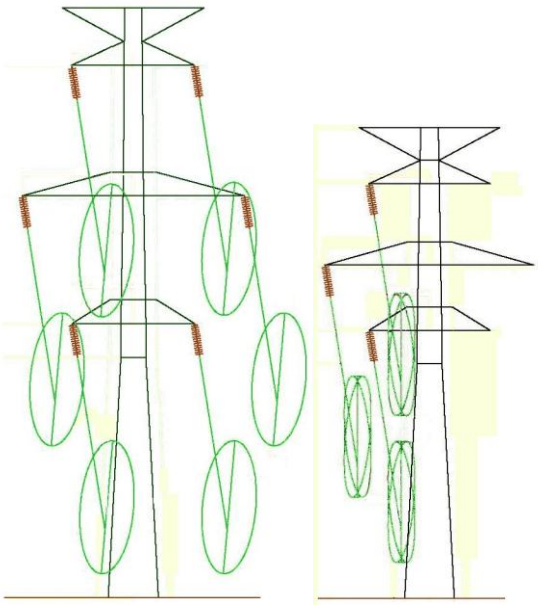
Figure 5 Running angle tower designs with galloping clearance envelopes Left: standard ellipse. Right: based on new approach [6]

Dynamic Loading

Galloping motions generate significant dynamic loads on structures, and can lead to various levels of damage. Figure 6 shows one example in which the lower arm of a dead end tower has collapsed from the repeated galloping loading [7].

There have been a few measurements of the dynamic loads during galloping. In a summary of these effects, these dynamic forces are shown to be up to twice the static vertical load of the iced conductor, and up to 2.9 times the static longitudinal tension [8]. These are impact loads that are repeated many times, as the galloping can continue as long as the ice or wet snow remains on the conductors and the wind is sustained. While the weather conditions causing galloping are often transient and pass in a few hours, the conditions can remain in place for several days.

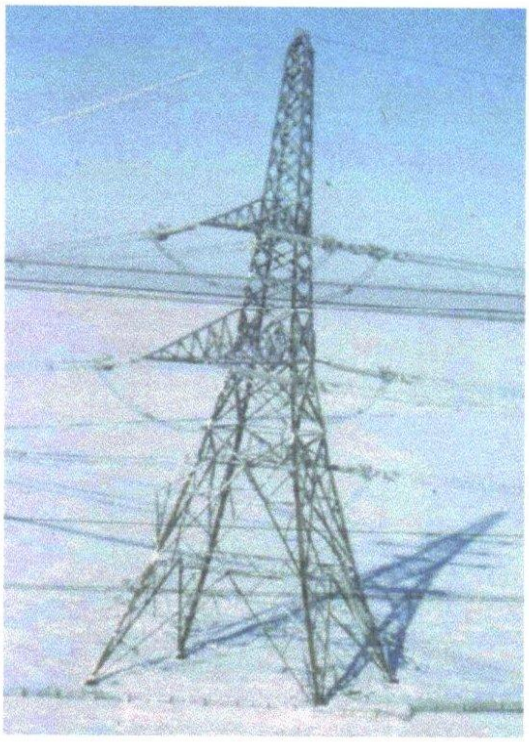

Figure 6 Angle tower with bottom arm collapsed due to galloping [7]

Further Analysis of the Galloping Data Bank

More sophisticated relationships were developed from the same set of field data later [9]. Better correspondence with the data was obtained when the peak to peak galloping amplitude, $A_{pk\text{-}pk}$, was divided by conductor diameter, D, and the span length, L, was represented by a conductor span parameter. This conductor span parameter was given by (1):

$$100\frac{T.D}{mg.L^2} = \frac{100.D}{8S} \qquad (1)$$

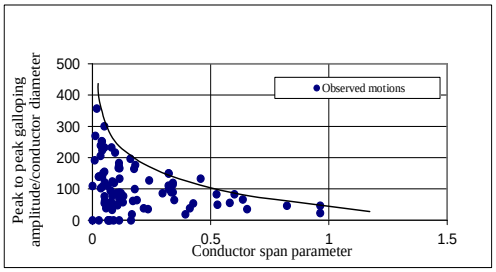

Figure 7 Observed maximum peak to peak galloping amplitude/diameter on single conductors versus conductor span parameter [9]

Where m is the mass of the conductor per unit length, g is the gravitational constant, and S is the sag of the span. This parameter has values in the range of 0.015 to 1.1, and generally the value is in reverse order to the span length. Fig. 7 shows the resulting relationship for single conductor observations and Fig. 8 for two-, three-, and four-conductor bundle data.

For single conductors, the fitted curve to the maximum amplitude over conductor diameter, which is included in Figure 48, is given by:

$$\frac{A_{pk-pk}}{D} = 80 \ln \frac{8f}{50.D} \qquad (2)$$

Where: f is the sag of the span.

This is valid only in the 0-1 range of the conductor span parameter, which corresponds to the data base range. For bundle conductors, the corresponding fitted curve, which is reproduced in Figure 8 as the estimated maximum, is given by:

$$\frac{A_{pk-pk}}{D} = 170 \ln \frac{8f}{500.D} \qquad (3)$$

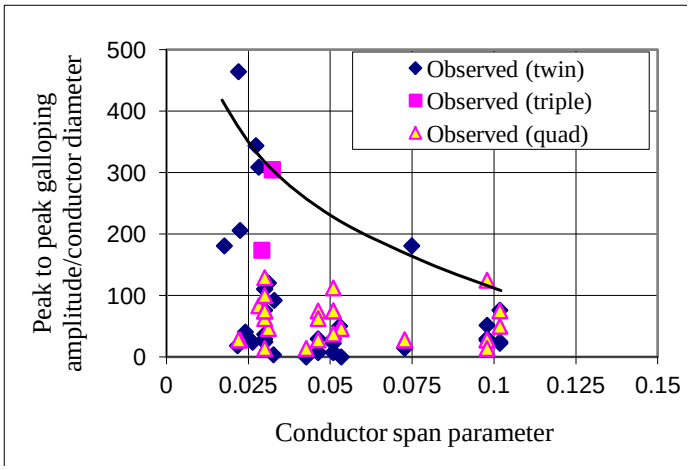

Figure 8 Observed maximum peak to peak galloping amplitude/diameter on bundle conductors versus conductor span parameter [9]

This is valid in the range 0-0.15 of the conductor span parameter.

This alternative analysis allows the maximum amplitudes under specific condition to be estimated. This analysis also conforms to the results of analytical modelling of galloping motions at the University of Liège [10].

Conductor Name (ACSR)	Aluminum Area mm^2	Stranding	Diameter mm	Unit Weight N/m	Rated Tensile Strength kN
Penguin	107.23	6/1	14.300	4.25	37.14
Drake	402.84	26/7	28.143	15.97	140.12
Bluebird	1092.26	84/19	44.755	36.65	268.23

Table 2 Properties of ACSR Conductors
Used in the Single and Bundle Conductor Examples [11]

Two examples of application of this more sophisticated data analysis are the effects of different conductor diameters and different conductor tensions. Three standard ACSR single conductors are considered with the properties given in Table 2. The predicted effect of tension is given in Figure 9 which shows that the predicted galloping amplitude is not strongly affected. Figure 10 shows that the galloping amplitude is strongly affected by conductor size. Similar results are predicted for bundle conductors [10]. However these results should be used with

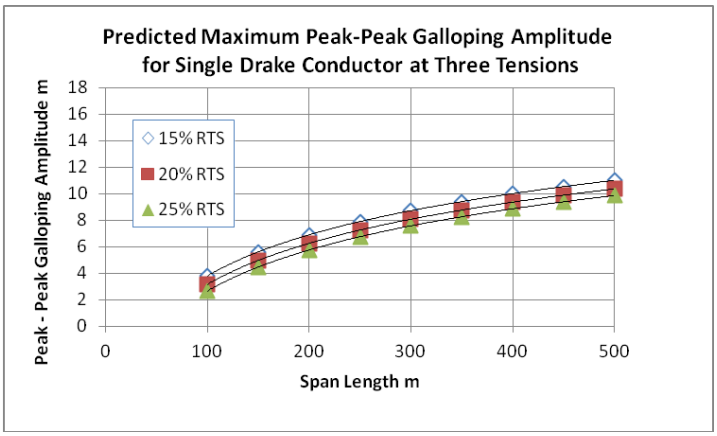

Figure 9 Predicted Maximum Peak to Peak Galloping Amplitude versus Span Length for single Drake ACSR Conductors for Three Tension Values [11]

caution as there were a limited number of actual galloping events at the extreme sizes and span lengths.

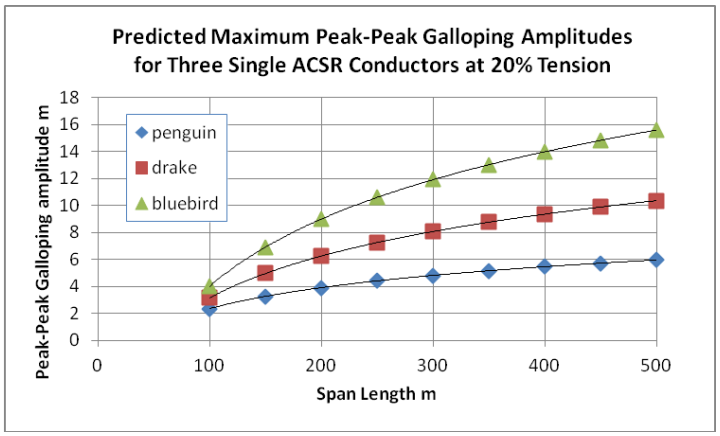

Figure 10 Predicted Maximum Peak to Peak Galloping Amplitude versus Span Length for Three Sizes of Single ACSR Conductor [11]

Galloping due to Wet Snow

The data base of observations used to develop the above was primarily from freezing rain conditions. The data on the effect of wet snow is more limited, but field studies of galloping of bundle conductor lines in Japan [12] have provided some insights which can be used to adjust the above procedures to galloping during wet snow events. One of the examples of galloping orbits from that study is shown in Figure 11 below, showing distinct lateral motions. A possible design practice is then to use the maximum amplitudes in accordance with the available data, as shown in Figure 3, with circumscribed circular envelopes to accommodate the galloping motions. Figure 12 illustrates an example of this approach for a location where wet snow events are known to occur each winter..

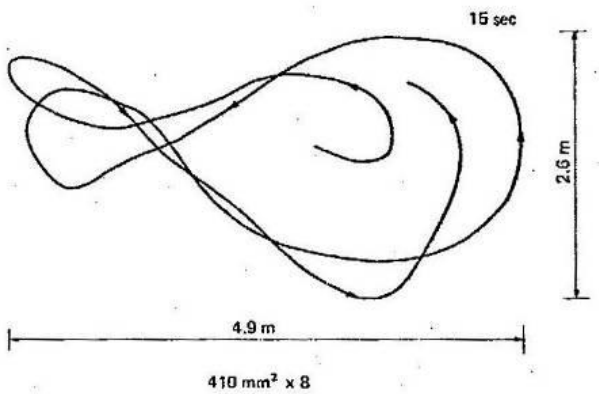

Figure 11 Galloping motions of an eight conductor bundle due to wet snow accretion [12]

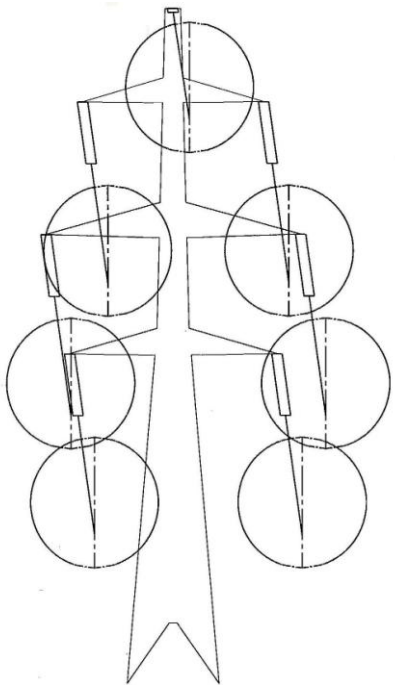

Figure 12 Example of circular galloping clearance envelopes for wet snow conditions

Conclusions

- Current practice for design of galloping clearance envelopes can be improved based on available field data
- A new envelope based on a narrower vertical envelope is described
- This new envelope has been used in the design of a new family of transmission towers
- The new towers are more slender and shorter resulting in reduced weight, cost and right of way requirements

- The available data and a modeling of the galloping mechanism have been used to develop alternative descriptions of galloping behaviour on single and bundle conductors
- This analysis allows the prediction of galloping motions on different conductors
- Effects of changes of tension are predicted to be small for both single and bundle conductor
- Larger galloping motions are predicted for larger conductors for both single and bundle lines
- Galloping with wet snow accretion has more horizontal motion and an alternative design practice for clearances is outlined.

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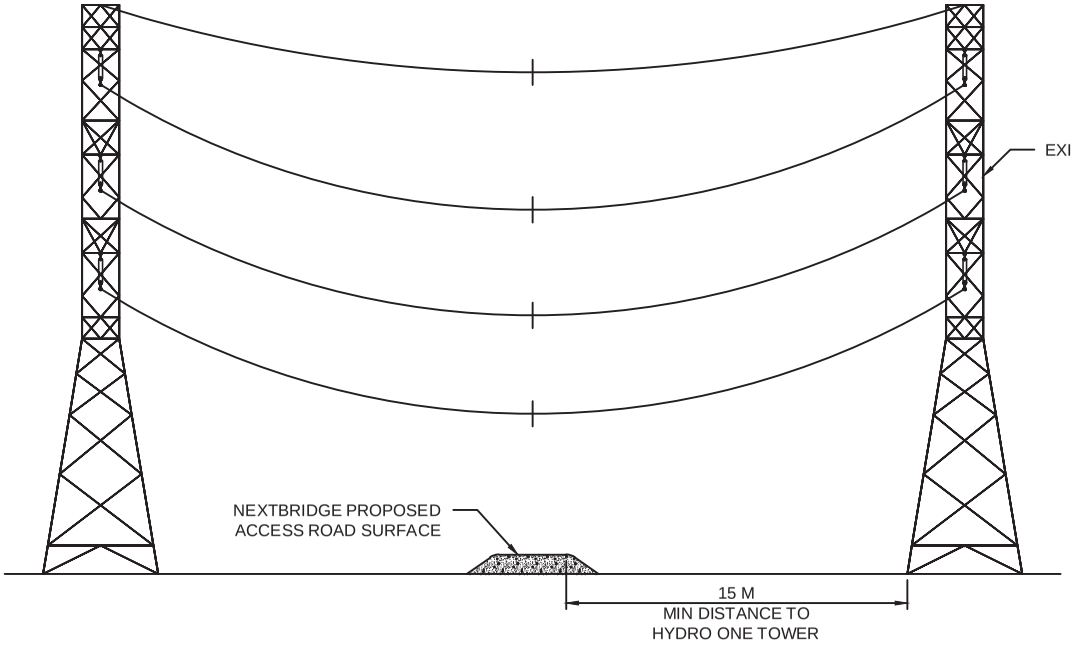
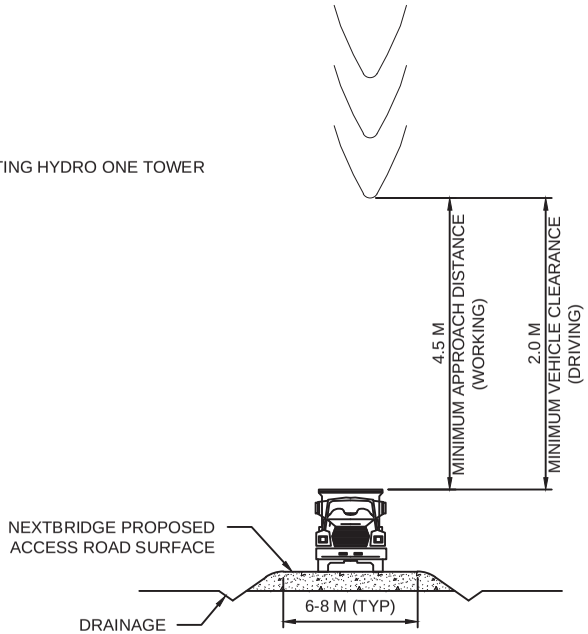
[11] D.G. Havard, "Towards a Guideline for Galloping Clearance Design", Presentation to IEEE Working Group on Overhead Conductors and Accessories, Memphis, January 2013
[12] S. Morishita, K Tsujimoto, M. Yasui, N. Mori, T. Inoue, K. Shimojima, and K. Naito, "Galloping Phenomena of Large Bundle Conductors, Experimental Results of the Field Lines", CIGRE Conf. Paper 22-04, 1984

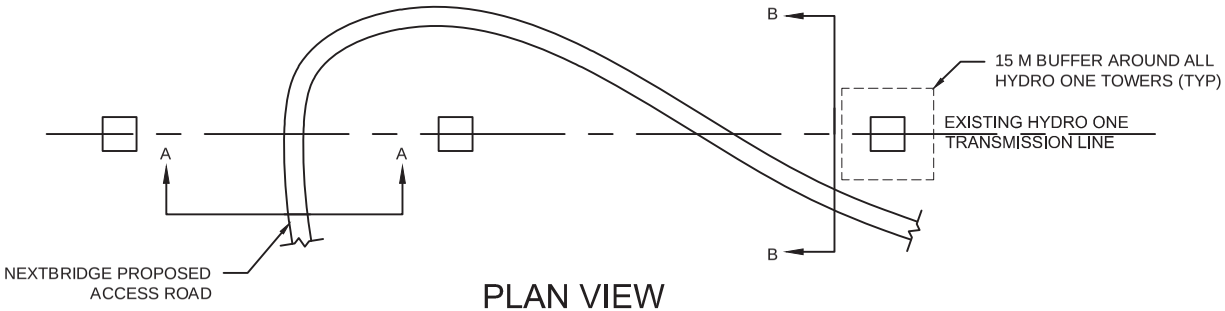
ATTACHMENT 3
TO HYDRO ONE NETWORKS INC. ARGUMENT-IN-CHIEF
DATED OCTOBER 22, 2018



SECTION A-A



SECTION B-B



PLAN VIEW

THIS DOCUMENT IS PRELIMINARY IN NATURE AND IS NOT A FINAL, SIGNED AND SEALED DOCUMENT.

NOTES:
1. WHERE ACCESS ROADS ENCROACH UPON THE 15M BUFFER INDICATED AROUND EXISTING TRANSMISSION TOWERS, TEMPORARY FENCING OR OTHER BARRIERS WILL BE INSTALLED TO PROTECT THE TOWER BASE AND IDENTIFY THE HAZARD TO CONSTRUCTION TRAFFIC.

no.	date	by	ckd	description
C	09/02/16	MSP	JPC	ISSUED FOR REVIEW
B	08/23/16	MSP	JPC	ISSUED FOR REVIEW
A	08/18/16	MSP	JPC	ISSUED FOR REVIEW

BURNS McDONNELL

PERMIT TO PRACTICE NO. 100155281
BMcD PROJECT NO. 78290 - 78311

date 08/18/2016
designed -
detailed M. PEPICH
checked J. CANNON

ONTARIO EAST-WEST TIE 230KV T/L PROJECT
CROSSING EXHIBIT
TYPICAL ACCESS ROAD

NEXTBRIDGE INFRASTRUCTURE

project 78311 | drawing 1234L-00991 | sheet 1 | rev. C

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