HISTORY AND STATUS OF SILICONE INJECTION TECHNOLOGY

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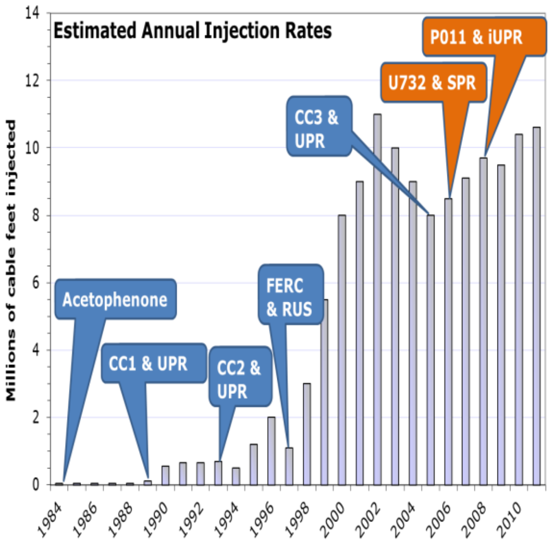
***Abstract*: Over twenty-five years have elapsed since the commercial introduction of the first solid dielectric enhancement technology. During those years, silane injection technology has proven itself as an important tool to enhance the reliability of aging infrastructure. Incremental improvements during those two-and-a-half decades have aided in the widespread commercial acceptance of the technology on four continents.**

This paper traces the evolution of dielectric enhancement technology, compares the merits of the available technologies, and provides a comprehensive bibliography. The merit comparisons are made in the broad categories of safety, short-term and long-term post-injection reliability, and end-user value.

INTRODUCTION

From 1984 through 2011, over 100 million feet of medium voltage underground power cable were treated with available injection technologies as shown in FIGURE 1. As demonstrated by [5], injection is typically a fraction of the cost of replacement and the economics are almost always in favor of rejuvenation. Undoubtedly the favorable economics of rejuvenation fueled the rapid growth depicted in FIGURE 1.



Cumulative injection compiled from dozens of industry sources including [1], [2], [3] and [4] demonstrate the growing importance of injection technology.
FIGURE 1

The first five years of commercial injection utilized acetophenone. While no cables treated with acetophenone ever failed in service, this technical success was not matched by commercial acceptance, largely because of the fugitive nature of acetophenone and the safety and economic penalties imposed by the need for an ongoing maintenance requirement to continually supply fluid to the cable. In 1989, a silicone fluid (phenylmethyldimethoxysilane) invented by Gary Vincent of Dow Corning and referred to as "CC1" [6] in FIGURE 1 was introduced. Because of its water reactivity, this new CC1 fluid largely eliminated the need for a continual supply of fluid, at least for about 10 years at lower temperatures.

About 5 years later in 1994, Glen Bertini and Vincent, et al, improved on the CC1 technology when they introduced an additive called trimethylmethoxysilane in [7]. The CC2 technology advancement solved a radial fluid distribution issue suffered by CC1 [7]. This reformulation together with the approval by the FERC and RUS of the capital treatment of multi-segment fluid injection were the foundation for the rapid growth of injection at the turn of the century. This growth faltered after 2002 when it came to light in [3] and [24] that the CC2 technology could cause methanolic corrosion to aluminum strands. It was demonstrated in [7] that $30\%_w$ of the trimethylmethoxysilane was preferred in the formulation together with $70\%_w$ of the CC1 fluid to achieve optimum fluid distribution and dielectric performance. In 2005, CC3 was introduced when the concentration of the trimethylmethoxysilane was reduced by a factor of six to $5\%_w$, ostensibly to reduce the likelihood of corrosion of aluminum strands [23] experienced by the CC2 chemistry discussed in [3] and [24].

Up until 2006, all of the cable rejuvenation used the Unsustained Pressure Rejuvenation (UPR) method that introduced fluid under low unsustained pressure (about 1 bar) into the cable strands through injection elbows and injectable live front adaptors. In 2006, the Sustained Pressure Rejuvenation (SPR) technology became possible with injection adaptors described in [31] and [32], which can permanently seal fluid in the strands. SPR uses a moderate pressure of 100 to 300 psi (7 to 21 bar) to dramatically improved post-treatment performance as demonstrated in [18]—7 days vs. 24 months. Injection pressures in excess of those utilized in the SPR process have been utilized routinely in the industry for over two decades. Even without the benefit of sustained pressure, moderate pressure injection has demonstrated an improvement in post-injection reliability, since at least 1987. For example in [33], injection pressures up to 1000 psig (68 bar) have beneficial effects on 1/0 cable per AEIC 582. In [34], [35], and [36], pressures of 350 to 500 psig (24 to 34 bar) are disclosed as routine.

The first fluid technology referred to as CCx (encompassing its three incarnations, CC1, CC2, and CC3) has been in widespread use since 1989 with the most recent formulation in use since 2005 and is defined by [6], [7], and [8]. The second fluid technology introduced commercially in 2007 and described in [25] is referred to as P011 and utilizes the same base silane as CCx, namely phenylmethyldimethoxysilane, but it can be delivered with new SPR technology and an improved catalyst package. The third fluid technology, referred to as U73x (where X=2 for URD cables and X=3 for larger cables) and described in [26], includes the field proven technologies of P011, along with completely new materials designed for very long life extension. The U73x technology was available for the first time in 2006 when the SPR technology was introduced. A more complete history down to the chemical component level for all rejuvenation formulations is found in [30] and [37].

The balance of this paper examines four dimensions to compare commercially available rejuvenation technology. Those four dimensions are safety, short-term post-injection reliability, long-term post-injection reliability, and end-user value. Three technologies will be compared.

SAFETY

Within the realm of safety there are two primary considerations in comparing rejuvenation technologies. The first is the exposure of injection contractors and circuit owner employees to high voltage. The second is the risk of fire and explosion.

When CCx technology is applied to URD cables at least three visits (i.e. 1-injection; 2-vacuum tank removal, typically 24 hours after injection; and 3-soak tank removal, 60 to 120 days after soak tank removal) are required to manipulate energized or potentially energized high-voltage components. Potentially energized bottles are left connected to terminations for a 60 to 120 day soak period. During that soak period, utility trouble-workers and line-workers may encounter unusual and potentially dangerous situations. Unfortunately, each exposure to high voltage runs the risk of accidental electrical contact.

In 2010, the improved Unsustained Pressure Rejuvenation (iUPR) process was introduced. This process eliminates the third visit and removes all tanks when the fluid flows to the other end of the cable, typically overnight. The improved catalyst makes the fluid more efficient, thus eliminating the need for a 60-120 day soak period.

Both the P011 and U73x technologies using the SPR process require a single visit and a single switching operation. There are no unusual pieces of potentially energized equipment left near terminations.

The CCx/UPR technology utilizes injection elbows with ports described in [9], [10], and [11]. These ports are momentarily open to an energized conductor as permanent shielded caps are substituted for injection caps. These open ports have been known to flash over and create a hazard to employees including fire and explosion hazards as described by [12] and [13]. There are mitigating technologies described by [12] and [13], which remain unimplemented to date. The iUPR process eliminates this hazard by utilizing a reticular flash preventer (RFP). [38]

SPR injection is completed in minutes on de-energized cable, and there is no open port injection into energized components.

TABLE 1
Safety Considerations

Consider:	**CCx/ UPR**	**P011/ iUPR**	**U73x/ SPR**
Injection contractor HV electrical exposure	3+	2	1
Utility personnel exposure to unusual and potentially energized equipment	Up to 120 days	24 hrs.	No
Potential flashover from open injection ports	Yes	No	No
Flammable	Yes	No	No
Known carcinogens	Yes	Yes	No
Known male reproductive toxins	Yes	Yes	No

Fire and explosion requires three components: fuel, oxygen, and a source of ignition. Unfortunately in a medium voltage distribution environment, both oxygen and ignition sources are ever-present. Not all fuels are equal when it comes to the ease of ignition. The ease of ignition is measured as a flash point and the higher the flash point the less likely the fluid will ignite. According to the current material safety data sheet (MSDS) of the CC3 fluid [14], its flash point is 13°C (55°F), well below the flash point of jet fuel A. Materials with low flashpoints are rated by the U.S. Department of Transportation (DOT) as flammable. The P011 and U73x fluids have flash points in excess of 61°C (142°F) and are not rated as flammable by the DOT {49 CFR 173.115-120} or OSHA {29 CFR 1910.1200(c)}.

The CCx fluid and P011 fluid include the carcinogen and male reproductive toxin benzene [14]. The U73x technology includes no known carcinogens or reproductive toxins.

SHORT-TERM RELIABILITY

Most post-treatment failures experienced with CCx/UPR technology occur shortly after treatment. For example in [15], Florida Power and Light (FPL) report a post-treatment failure rate of close to 5%. FPL primarily utilized injection on segments, which had recently failed. Another example, provided by [16], is Salt River Project (SRP), which reports a failure rate of about 1% during the first two years on proactive injection. The high short-term post-injection failure of CCx technology is exasperated by at least two characteristics of the CCx approach. First, there are no provisions in the CCx fluid technology to address partial discharges (PD). Secondly, as demonstrated in [17], it takes about two years after treatment for CCx/UPR technology to reach its maximum performance. Capital constrained cable owners often delay their treatment programs until the cables have demonstrated that they are nearing the end of their reliable life. In these circumstances, rapid rejuvenation is desirable to avoid early post-treatment failures.

In [18], it was demonstrated that the P011 and U73x technologies injected with the SPR method enjoyed an 87-fold faster performance increase compared to CCx/UPR method. Put another way, cables treated with P011 and U73x technologies and SPR perform with an AC breakdown strength comparable to new cables within a week of treatment. See TABLE 2.

Third and fourth short term considerations are fluid incompatibility with components including elbows, terminations and splices. In [29], it was shown that where molded components are purposely exposed to silicone treatment fluids with the CCx injection paradigm there are two undesirable consequences. First, a portion of supplied fluid is simply lost to the highly permeable EPDM splices and elbows typically employed to inject the cable. This lost fluid reduces the amount of fluid available to treat the cable. Second, fluid does sometime damage molded rubber components, particularly in higher soil temperatures and higher operating temperatures.

TABLE 2
Short-Term Performance Considerations

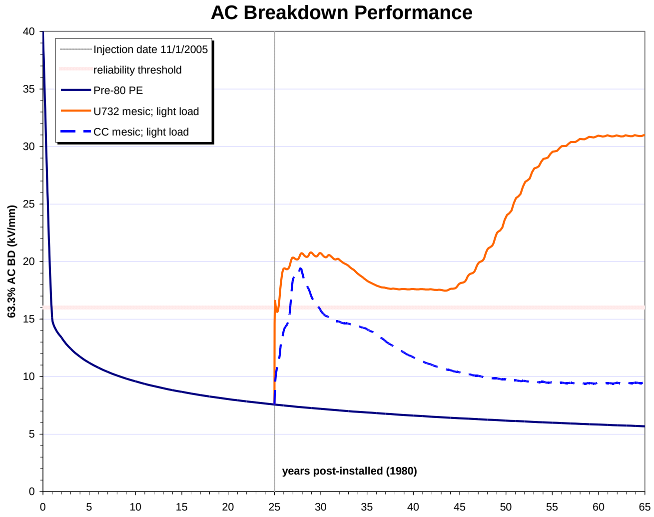
Consider:	**CCx/ UPR**	**P011/ iUPR**	**U73x/ SPR**
Functionality included in technology to address partial discharges	No	No	Yes
Dielectric performance of cable greater than 16 kV/mm (400 v/mil) within one week of treatment	No	No	Yes
Fluid loss to molded components	Yes	Yes	No
Potential damage to molded or shrink-in-place components	Yes	Yes	No
Symmetrical penetration profile	No	No	Yes

As described in [30], the 2005 decreased amount of the fast-to-diffuse trimethylmethoxysilane component in the CCx fluid (CC2 → CC3) has profound short-term performance consequences. In short, and particularity acute with cables with 37 or more strands, the CC3 technology has a less than optimum penetration profile.

LONG-TERM RELIABILITY

In two-part paper [19] and [20], methods for the estimation of life for various conditions for each of the three technologies were provided and those estimations were validated against available accelerated-life data. The CCx and P011 technologies utilize a single formulation for all conditions. As indicated by [19] and [20], while this one-size-fits-all strategy might simplify the operations of those performing the injection, inherent performance compromises are required as even modest temperature differences have a profound influence on long-term performance.

FIGURE 2 provides a validated simulation (see [19] and [20]) of post-injection performance for a 1/0 URD cable buried in mesic soils (e.g. above the Mason-Dixon Line) in 1980 with a moderate load. The reliability threshold of 16 kV/mm (400 v/mil) was established by Steennis [21] as a level where no failures are likely to occur in service.



Post-treatment AC breakdown for lightly loaded cables in mesic (15°C) soils.
FIGURE 2

The CCx/UPR approach suffers from a failure to stay in the insulation at a sufficiently high concentration for the long-term. CCx drops below the reliability threshold after about 5 years. P011 provide about a 30% boost in that performance, because of the catalysis improvements described in [25]. In contrast, the U73x technology tailors the formulation for the anticipated thermal conditions the cable will face over its desired lifetime. With a temperature-adjusted formulation, U73x can stretch life by 40 or more years for any cable, in any soil, with any anticipated load.

A theoretical framework and data to explain the substantial post-injection performance enjoyed by the U73x technology was provided in [26]. TABLE 3 provides a high level review of some of the key differences described there.

TABLE 3
Long-term performance considerations

Consider:	**CCx**	**P011**	**U73x**
AC BD performance > 16 kV/mm	yrs	yrs	yrs
• mesic soils; light load	5	10	>40
• thermic soils; moderate load	4	4	>40
• hyperthermic soils; heavy load	1	1	>40
Volume tailored to cable geometry	No	Yes	Yes
Chemistry tailored to cable conditions	No	No	Yes
Includes stress grading	No	No	Yes
Includes voltage stabilization	No	No	Yes
Includes UV stabilization	No	No	Yes
Includes antioxidant	No	No	Yes
Includes PD suppression	No	No	Yes

VALUE

In the end, circuit owners must weigh performance and economics in their decision-making process. There are a wide variety of conditions that affect cost. Individual circuit owner costs may vary from the typical case provided in TABLE 4.

Along with cost comes the confidence that the technology will perform as anticipated. One of the authors invented all three technologies compared in this paper and our collective representations have stood the test of time and peer review. All three technologies come with warranties that are far superior to the warranties offered by cable replacement contactors or cable manufacturers. Contrary to some public representations [22] however, there are no fully insured warranties.

When it comes time to collect on a warranty decades after treatment, the circuit owner must judge the ability of the warrantor to pay in an uncertain future. In most cases, faith is better placed upon individuals than faceless institutions. For long-term warranties, however, some institutional trust is required. There are at least five elements to be considered to differentiate the commercially available warranties.

1. What conditions are established by the warranty provider to restrict a remedy?
2. What is the warranty length?
3. What portion of the warranty obligation is insured?
4. Is there an actual fund of cash held by a third-party and accumulating interest to pay long-term obligations?
5. What is the history and future of the ownership and management teams for the suppliers?

The summary answers for each of these questions are found in TABLE 4.

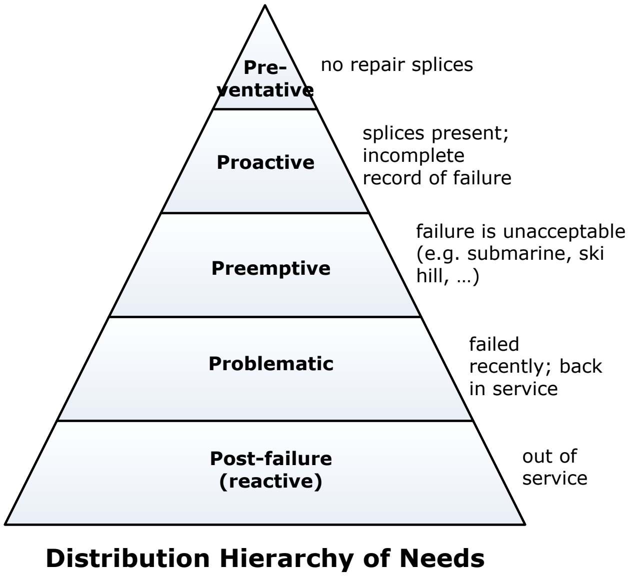
TABLE 4
Value Considerations

Consider:	**CCx/ UPR**	**P011/ iUPR**	**U73x/ SPR**
Typical fully absorbed cost as a percentage of replacement (single phase, direct buried, 1/0 15kV cable)	40%	35%	41%
Unconditional warranty	No	Yes	Yes
Warranty length in years	20	20[1]	40[2]
Warranty fully insured	No	No	No
Warranty funding held in appreciating 3rd-party trust	No	Yes	Yes
Management team with >2 decades of experience	No	Yes	Yes
Developed by technical team with >2 decades of experience	Yes	Yes	Yes
State-of-the art in …	1994	2007[3]	2006

Notes: [1]Warranty is available only for lightly loaded cables in cool soils; [2]40 year warranty is available only for cables with 19 or more strands – 7-strand cable has 20-year warranty; [3]P011 is an improved version of CCx and while introduced in 2007, it was never state-of-the-art.

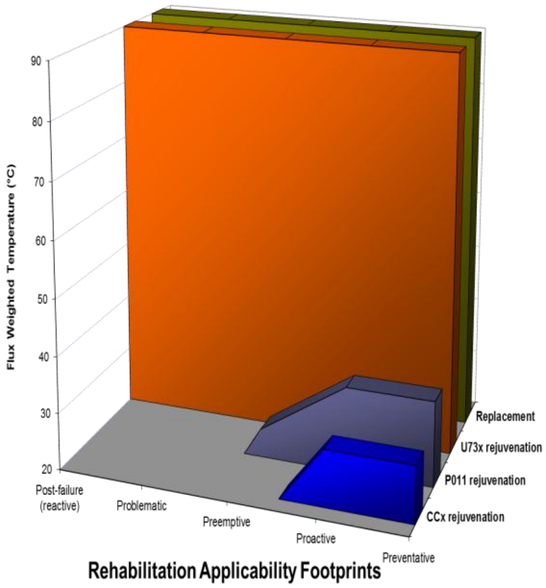
In [27], a framework for strategic prioritization is provided which defines the distribution hierarchy of needs reproduced here as FIGURE 3. In short, CCx/UPR and P011/iUPR technology is only applicable to the highest portions of the FIGURE 3 pyramid, namely preventative and proactive. Those two technologies were simply not designed to address the bottom of the pyramid. Taken together with the thermal restraints on the three rejuvenation technologies, it is possible to build an applicability footprint as shown in FIGURE 4.

Of course, replacement can always be used for any strategic requirement and up to the design temperature of the cable. However, at several times the cost of rejuvenation, there are capital efficiency considerations which encourage rejuvenation to be considered. CCx/UPR rejuvenation is constrained on the top of its FIGURE 4 footprint by its one-size-fits-all chemistry



The hierarchy sorts strategic cable rehabilitation funding priorities from the bottom up. The final comparison hinges upon the applicability of each technology to the strategic needs of the circuit owners.

FIGURE 3



Thermal performance and strategic applicability define envelopes for each of the 4 rehabilitation tactics.

FIGURE 4

and on the left by its lack of functionality for cables, which have already failed. P011/iUPR improves slightly on both of these accounts. With 30% greater longevity, a slightly higher temperature can be tolerated. With an injection paradigm designed from the beginning to deal with the splices inherent on proactive work its footprint extends to the left of CCx/UPR rejuvenation. U73x/SPR was designed from the outset to address the most problematic cables and hence covers all 5•Ps.

SUMMARY

Rejuvenation technology is almost always the most cost effective rehabilitation strategy. The circuit owner has three rejuvenation technology choices. The most recently developed technologies, P011/iUPR and U73x/SPR, enjoy superior safety, short-term performance and value compared to the older CCx/UPR technology. The U73x/SPR technology outperforms the CCx/UPR and P011/iUPR technologies by over a factor of 3 in long-term reliability performance. For the cost conscious buyers, the advantages of P011/iUPR can be enjoyed at a lower cost than the CCx/UPR technology with a slightly improved performance. In light of recent discoveries, neither the CCx/UPR nor the P011/iUPR technologies should be employed:

1. In the warmer soils common below the Mason-Dixon line,
2. Where cable loading exceeds 25% of rated ampacity, if 20-year post-injection reliable life is desired, or
3. Where the strategic position of the cable is post-failure, problematic or preemptive.

REFERENCES & BIBLIOGRAPHY

References 1 through 38 are cited in this paper. References 39 and up are provided as bibliography to the reader interested in a thorough examination of chemical rejuvenation technology.

1. Tarpey, "Cost Effective Solution to URD Reliability: Cable Rehabilitation", Pennsylvania Electric Association T&D Committee Meeting, May 8, 1990.

2. Bertini & Chatterton, “Dielectric Enhancement Technology”, IEEE Electrical Insulation Magazine, March/April 1994-Vol.10, No.2, pp 17-22.

3. Bertini, "Failures in Silicone-Treated German Cables Due to an unusual Methanol-Aluminum Reaction", ICC meeting Minutes, October, 29 2002, p. 1104.

4. Bertini, "Injection Supersaturation in Underground Electrical Cables", U.S. Patent 6,162,491.

5. Bertini, “Advancements in Cable Rejuvenation Technology”, IEEE/PES 1999 Summer Meeting, Reliability Centered Maintenance, July 21, 1999.

6. Vincent & Meyer, “Restoring Stranded Conductor Electrical Cable”, U.S. Patent 4,766,011.

7. Bertini, Vincent et al, "Method for enhancing the dielectrical strength of a cable using a fluid mixture", U.S. Patent 5,372,841.

8. Bertini, "Injection Supersaturation in Underground Electrical Cables", U.S. Patent 6,162,491.

9. Borgstrom & Stevens, “Separable Connector Access Port and Fittings”, U.S. Patent 4,946,393.

10. Borgstrom, Bertini & Meyer, “Removable Media Injection Fitting”, U.S. Patent 5,082,449.

11. Muench, et al, “High Voltage Electrical Connector with Access Cavity and Inserts for Use Therewith”, U.S. Patent 6,332,785.

12. Bertini & Stagi, “Method and Apparatus of Blocking Pathways Between a Power Cable and the Environment”, U.S. Patent 6,517,366.

13. Bertini & Stagi, “Method and Apparatus of Blocking Pathways Between a Power Cable and the Environment”, U.S. Patent 6,9292,492.

14. MSDS dated 05/14/2005, downloaded by author 01/12/2006 & available online at http://www.utilx.com/pdfs/MSDS_XL_Fluid.pdf.

15. Dudas & Fletcher, “Underground Cable Specification Advances and Installation Practices of the Largest Investor-Owned Utilities”, IEEE Electrical Insulation Magazine, V.21. No.4, July/August 2005.

16. Hudson & Crucitt, Salt River Project, “SRP Enhances Reliability of Underground Distribution Cable”, Transmission & Distribution World, Aug 1, 2000.

17. Mokry et al, "Cable fault prevention using dielectric enhancement technology", Jicable 1995.

18. Bertini, “New Developments in Solid Dielectric Life Extension Technology”, IEEE ISEI, Sept. 2004.

19. Bertini, “Accelerated Aging of Rejuvenated Cables – Part I”, ICC, Sub. A, April 19, 2005.

20. Bertini, “Accelerated Aging of Rejuvenated Cables – Part II”, ICC, Sub. A, November 1, 2005.

21. Steennis, “Water Treeing: The behavior of water trees in extruded cable insulation”, Ph.D. Thesis, 1989, published by KEMA.

22. See unsubstantiated claim: “This outstanding warranty … is fully insured.” at http://www.wiredynamix.com/power/warranty.aspx.

23. Stagi, “The Evolution of Cable Injection Technology”, 2004 Fall ICC, Subcommittee A.

24. Brüggemann et al, “Influence of Electrochemical Effects on Vented Tree Initiation in Accelerated Tests”, Jicable 2003 - International Conference on Insulated Power Cables, 2003.

25. Bertini & Vincent, “Advances in Chemical Rejuvenation: Extending medium voltage cable life 40 years”, Jicable 2007 – International Conference on Insulated Power Cables, 2007.

26. Bertini & Vincent, “Cable Rejuvenation Mechanisms”, ICC, Sub. A, March 14, 2006.

27. Brinton, “Underground Distribution Reliability: The 5•Ps”, Electric Energy, Issue 1, 2007.

28. Bertini & Kleyer, “The Extension of CableCURE Dielectric Enhancement Technology to Feeder and 35kV Cables”, 45th Annual Power Distribution Conference, Austin, TX, 10/19/92.

29. Bertini, “Improving Post-treatment Reliability: Eliminating Fluid-Component compatibility Issues”, ICC DG C26D, Nov. 1, 2005.

30. Bertini & Vincent, “Rejuvenation Reformulated”, ICC SubA, May 8, 2007.

31. Bertini & Theimer, “High Pressure Power Cable Connector”, U.S. Patent 7,195,504, Mar. 27, 2007.

32. Bertini & Theimer, “High Pressure Power Cable Connector”, U.S. Patent Application 2007-0169954, July 26, 2007.

33. Vincent & Meyer, “Silicone Water Block for Electrical Cables”, U.S. Patent 4,845,309, Filed Apr. 23, 1987.

34. Lanan, Chau, & Stagi, “Cable Connector with Fluid Injection Port”, U.S. Patent 5,907,128, filed Feb. 13, 1997. (See column 3, line 26.)

35. Jenkins, K. “Submarine Cable Rescued with Silicone-Based Fluid”, Minutes of Spring 2000 ICC, pp. 336-353.

36. Van Horn letter to Bertini, November 7, 2005, “UTILX has for years treated power cables with pressures … sometimes even exceeding 500 psi.”, letter available from author upon request.

37. David Busby & Glen Bertini, “Cable Rejuvenation Mechanisms: An Update”, CIGRÉ Canada Conference on Power Systems, Vancouver, BC, October 17-19, 2010.

38. Glen Bertini, Norm Keitges, & Don Songras, “Advancements in 200-AMP Injection Elbows, ICC Sub B, May 20, 2009.

--------------------**Additional Bibliography**------------------------

39. Bertini, "Method of Suppressing Supersaturation", ICC meeting Minutes, October, 27 1998 pp 116-118.

40. Bertini, “Entergy Metro Case Study: Post-Treatment Lessons”, Minutes of Spring 1997 ICC, Appendix 5-B.

41. 5. Sheil, “Solid Dielectric Cable Rejuvenation Technology”, EDIST Jan. 22, 2003.

42. Kleyer & Chatterton, “The Importance of Diffusion and Water Scavenging in Dielectric Enhancement of Aged Medium Voltage Underground Cables”, Proceedings of the IEEE/PES Conference April 1994.

43. Jenkins & Bertini, "Fourth Generation Dielectric Enhancement Technology", Jicable 1998.

44. Stagi, “The Evolution of Cable Injection Technology”, 2004 Fall ICC, Subcommittee A.

45. Gurniak, “Neutral Corrosion Problem Overstated Recent study suggests problem may not be as serious as once thought”, Transmission & Distribution World, Aug 1, 1996.

46. Chatterton, Stagi, et al, “Electrical Cable Restoration Fluid”, International Patent Publication Number WO 2006/119196 A1.

47. Gutierez, “Underground Cable Life Extension”, EEI Electrical System & Equipment Committee, 2/20/91.

48. Bertini, "Feeder Cable Failures at APS", Fall 1991 ICC.

49. Bertini, “Advances in Chemical Rejuvenation of Submarine Cables”, Jicable 2007 – International Conference on Insulated Power Cables, 2007.
50. Bertini, “Recent Advancements in Cable Rejuvenation Technology”, IEEE/PES Summer Meeting, 1999.
51. Bertini & Piling, “Incorporating CableCURE Injection into a cost-effective Reliability Program”, IEEE Industry Applications, 2000.
52. Faremo, “Restoration in Sandnes. Laboratory Tests at SINTEF Energy Research up to and including one year of service after restoration”, copy available from author.

Glen J. Bertini is the President, CEO, Chairman, and Founder of Novinium, Inc. He has spent the last twenty-five years working with cable rejuvenation technology beginning with its development at Dow Corning in 1985 and continuing through its commercialization and growth to over 100 million feet of cable rejuvenated so far. Mr. Bertini was employed by Dow Corning, a silicon chemical manufacturer, as a development engineer, where he focused on the thermodynamics of multi-component systems and was part of a small team that developed and commercialized the first cable rejuvenation products. With over 50 articles published on the subject of cable rejuvenation technology, Mr. Bertini is the world's foremost authority. Mr. Bertini holds a total of 27 patents on cable rejuvenation and related technologies and has several more pending. In 1992, he was co-recipient of the prestigious R&D 100 award for cable rejuvenation. In 2006 Mr. Bertini and Novinium won the $100,000 Zino Zillionaire Investment Forum award for the best investment opportunity in the Pacific Northwest. Mr. Bertini holds a B.S. in Chemical Engineering from Michigan Technological University, is a Fellow of the IEEE, a voting member of the PES/ICC, and is a licensed professional engineer.

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