

Kensington

Concerns and Issues
Regarding Underground
Installations of
Transformers
(revised)

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Introduction

The Kensington Report entitled “Concerns and Issues Regarding Undergrounding” includes the following paragraph: “Communities might accept [above-ground transformers that negatively impact curb appeal and diminish home values] as an undergrounding trade-off, if there were no safe and environmentally friendly options. However, that is not the case. DuPont recently introduced a transformer specifically designed for vaults, which they claim addresses legitimate safety and environmental concerns. The Los Angeles Department of Water and Power (DWP) and Southern California Edison (SCE) have already started limited use of these transformers, lending credibility to DuPont’s assertions.”

This report shall elaborate on the DuPont transformer’s role as a readily available option for undergrounding in Kensington. The industry literature refers to it as the DuPont™ ReliatraN™ SIDT (Solid Insulation Distribution Transformer). It uses solid material instead of oil for insulation and has proven to be reliable, safe, and environment friendly. For easier understanding, I have presented its detailed properties and capabilities in Appendix I, Subsurface Versus Pad-mounted Equipment, along with unaltered statements taken from a project management fact sheet published by SDG&E entitled Subsurface Versus Pad-mounted Equipment.

The ABB Era

Actually, the SIDT concept is not a new one as evidenced by the following news releases:

November 28, 2002, ABB (Asea Brown Boveri Ltd) (excerpted):

“ABB and Hydro-Québec, the big Canadian utility, recognized the need to design a completely new transformer which would address and resolve all electrical and environmental issues. The two companies formed CITEQ, a joint venture business, to develop the revolutionary Solid Insulation Distribution Transformer (SIDT). The SIDT is now on trial at some 300 locations across North America, exposed to a range of climatic and operational conditions. The new design is also suitable for European three-phase operation.

“The SIDT is designed to meet the requirements of local infrastructure planning, and eliminate unsightly above-ground structures. It is installed underground even in land subject to chemical flows, including fertilizers, places where ordinary steel transformers cannot operate. Some are even operating underwater to demonstrate their integrity and safety. The SIDT offers significant improvements in performance and reliability over conventional distribution transformers.”

September 1, 2005, HECO (Hawaiian Electric Co (abridged):

“Hawaiian Electric Co. (HECO) is the first utility in the world to install an ABB Solid Insulation Distribution Transformer (SIDT) on a pole. Located in an environmentally sensitive location next to a waterway, the use of the SIDT eliminates the possibility of an oil spill that could create serious negative publicity and cost as much as US\$75,000 to clean up. SIDTs were developed by CITEQ, a joint venture between Canadian utility Hydro-Québec and ABB. [snip] Of the approximately 500 units installed in North America, some are directly buried or submerged in saline water.”

In fact, several of the “old” ABB SIDTs have been installed for many years both at LADWP (Los Angeles Department of Water & Power) and SCE (Southern California

Edison) where they are still operating successfully. As with any new product development, ABB continued to refine the design and manufacturing processes over time. By late 2005, just prior to ceasing production of their SIDT, ABB along with its joint venture partners had been planning to implement a series of improvements; however, this effort would have required a significant investment that ABB and its joint venture partners were unwilling or unable to commit to.

The DuPont Era

The DuPont™ ReliatraN™ SIDT¹ incorporates the original patented design of the ABB SIDT, along with the previously planned improvements and a number of additional enhancements. As is customary in the electrical industry, the DuPont SIDT was fully retested by third party testing laboratories *albeit beyond industry requirements* to revalidate the design changes.

The major improvements and their benefits can be summarized as follows:

1. The outer shell was changed from fiberglass to thermal plastic. This change improves cooling by transferring heat through the outer shell, and the dimensional consistency of the outer shell.
2. The lifting tabs that penetrated the outer fiberglass shell were replaced with an independent lifting cradle. This change eliminates the possibility of placing high mechanical stresses on the outer shell which could cause surface cracking.
3. The design was changed to increase energy efficiency: in 2010 the US Department of Energy mandated the utility industry to install greater energy efficient transformers. The design changes meet this requirement.
4. Stricter test procedures were adapted for verifying the quality of the epoxy cast coil process.

With these four points in mind, one may reasonably conclude that DuPont has significantly upgraded the original ABB SIDT and, as a result, increased its reliability and rendered it more energy efficient.

Based on their excellent experience with the earlier version of the SIDT, as well as test results and extended warranties pertaining to the upgraded version, both LADW&P and SCE have ordered, installed, and/or have in inventory substantial numbers of DuPont SIDTs. References at LADWP and SCE can be made available upon request.

Current Situation

An earlier version of this report elicited the following response from SDG&E in an email by Stuart Wells, Public Affairs Strategy Manager:

“It appears that ABB no longer sells these units. You must buy directly from DuPont, the original manufacturer. These are not routinely installed items at SCE or LADWP as one might believe, and their use is far from widespread. In addition, the cost is significantly more than our padmounted transformers that cost something on the order of \$3-4k. It would be quite expensive for SDG&E to certify DuPont as a vendor for this product given the uncertainty of the quantity we would be purchasing and the unproven nature of the installation. Therefore, I do not believe this is something we will be pursuing.”

¹ a rendering is included in the appendix

The SDG&E response is not surprising, for it erroneously assumed that the DuPont SIDT is a new product versus an enhanced version of the ABB product that has been installed successfully by the hundreds as evidenced in the news releases referenced above.

The one remaining valid objection to installing the current SIDTs is their significant incremental cost. A cost analysis based on numbers provided by DuPont indicates that the *incremental* cost of an SIDT over a padmounted transformer is about \$15,000. (A representative from SCE puts this figure closer to \$13,000). Assuming that each transformer serves between 7.5 and 10 private homes, one arrives at an *incremental* cost of \$1,500 to \$2,000 per private property.

It would be unrealistic to assume that the incremental costs of the DuPont SIDT be assumed by either the City of San Diego or SDG&E as there is no budget or additional income stream to pay for them, either now or in the years to come. Be that as it may, the bottom line is that SDG&E is unwilling to fund the incremental costs because they do not have to. The inexpensive padmounted transformer will do the job so why incur a significant additional expense? The aesthetics are not a factor in their decision making.

Fortunately, there is an alternative. This is based on the assumption that, if the residents of Kensington are sufficiently committed to the installation of subsurface transformers, they should be willing to pay for them, namely through the means of a Maintenance Assessment District (MAD) to be administered by the City of San Diego. By means of a MAD, each resident can be assessed a fair share of the incremental cost of the undergrounded or vaulted transformers based on some reasonable criterion, perhaps the square footage of their home. For a MAD to take effect, it has to be subjected to a ballot by the residents. For additional information on MADs, use the following link <http://www.sandiego.gov/park-and-recreation/general-info/mad.shtml>.

Because initiating a MAD would entail a significant effort, it might be prudent to informally gauge the willingness of the residents to accept an assessment via a survey that could be conducted by email involving a statistically significant subset of the citizenry.

Conclusion

As a result of the SDG&E response (which, in large part, represents a lack of understanding of what was proposed earlier), I have gathered and reported on (see the DuPont Era, above) specific technical information from DuPont that substantiates the premise that the DuPont SIDT is not a new product based on an old design but rather an upgraded version of the ABB SIDTs that have proven themselves to be effective and reliable over the past seven years.

In addition, DuPont has stated that they would provide an extended warranty for their SIDT, likely for five years rather than the standard one year.

I would hope, therefore, that the Undergrounding Subcommittee will seek out a way of presenting the facts contained in this report along with any desired additional information in a face to face meeting with high level management at SDG&E and the City. Larry Steiner, the SIDT Product Manager at DuPont has indicated his willingness to attend such a meeting.

Post Scriptum

In addition to implementing a vaulted transformer Assessment District for those residents of Kensington who are not presently undergrounded, it might also be advantageous to include those residents, mainly on Ridgeway and Palisades, who do have underground oil insulated transformers installed. This would avoid the potentially touchy issue of what to do with their oil insulated transformers when they ultimately fail. Because they were installed in the early 1970's, some if not all of these transformers are now close to 40 years in service. For their peace of mind, those residents may wish to be included in a Maintenance Assessment District and thus have their old transformers replaced with new ones.

Appendix I

SUBSURFACE VERSUS PAD-MOUNTED EQUIPMENT

SDG&E: The history of subsurface equipment at San Diego Gas & Electric Company (SDG&E) goes back to its use by the Southern California Edison Company (SCE). SDG&E followed SCE's lead in implementing this equipment in some communities near the SDG&E and SCE service boundaries. After a short time it was determined that this was not the best way to construct a distribution circuit. For over 30 years, SDG&E has not used subsurface equipment in new construction. The few remaining installations are still maintained and regularly reviewed and converted to pad-mounted surface equipment on a case-by-case basis. Subsurface installations are no longer approved for new construction at SDG&E for several reasons:

DuPont: By the early 1970's many Utilities were routinely applying medium voltage underground cables and oil-filled submersible transformers in vaults for residential applications. This was in response to the increased public demand, during the 1960's, for improved aesthetics. However, these underground systems were beginning to have higher than expected reliability problems and solutions were needed to make "total underground" installations sustainable.

Investigation of premature underground cable failures by material scientists eventually led to the discovery of a partial discharge failure phenomenon called "treeing" which was attributed to the use of hydrophobic polymeric cable insulation materials when they are exposed to a combination of moisture and electrical stress. The cable industry and science responded and over the next decades continuous improvements were made in cable design, polymer insulation composition and cable manufacturing processes. Today, virtually every Utility extensively uses underground medium voltage cable with confidence.

The main problem with underground transformers was largely due to the wet environment in which oil-filled transformers, encased in painted steel tanks, had to operate. Corrosion eventually reduced transformer reliability and increased maintenance due to tanks rusting and oil leaks. Safety concerns were also an issue because it is difficult to operate transformers inside deep vaults. Finally, oil leaks posed an environmental and financial risk problem. The U.S. Environmental Protection Agency (EPA) mandates that transformer mineral oil must be managed as a hazardous material in the event of spill. It is more difficult to detect an oil leak in underground installations. Because no complete solution for improving underground transformer technology was created, the pad-mounted transformer evolved.

However, over time the preference by developers and homeowners for total underground residential installations has not diminished and now there is a reason for Utilities to reconsider this option. The DuPont™ Reliatera™ solid insulation distribution transformer (SIDT) is a major advancement in distribution transformer technology. It was developed to solve the past problems with oil filled submersible transformers and is based on advancements in material science. Here are some considerations:

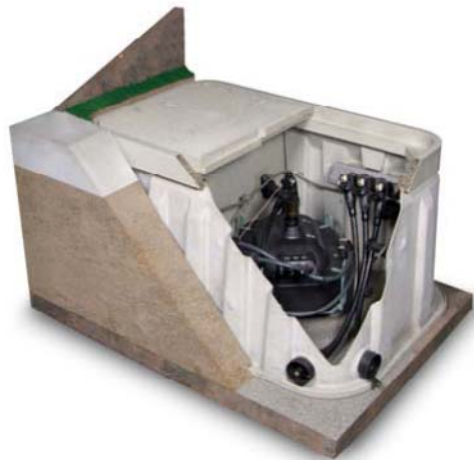
Safety

SDG&E: Operating and maintaining underground distribution equipment in confined spaces poses a significant safety hazard to personnel. Most types of distribution equipment use oil as an insulating medium, and this equipment can fail during normal operation and maintenance. This type of failure in confined spaces can result in injury or death.

DuPont: The dielectric system of the SIDT is made entirely of DuPont Nomex® and a solid epoxy; it does not contain oil or any other type of fluid. Therefore, testing has shown that, when subjected to a sustained fault condition, an SIDT failure mode is less severe (no flying parts).² Finally, compared to oil filled transformers, SIDT solid dielectric construction is fire-resistant and self extinguishing. While IEEE Standards do not exist to test for fire-behavior, SIDT technology was tested to, and complies with, IEC 60076-11 fire test F1 Class Standard³

Installations can be designed to enable linemen to operate an SIDT similar to a pad-mounted transformer. Due to their compact size, ReliatraN™ SIDT units may be mounted in smaller, lower profile vaults and by integrating a three-way HV junction mounted toward the top of the vault, the SIDT can be operated with a hook-stick, standing away from the equipment, similar to a pad-mounted transformer (see installation rendering, below).

Due to its compact size (75 kVA units are about 19” high), the SIDT contains no factory installed accessories except for 200 ampere HV busing wells with inserts, parking stand, 90 cm long low voltage cables, ground pads and a 4-point lifting device. Elbows, fuses, and other accessories required for installation must be installed externally to the transformer (but optionally within the same vault).



Operability

SDG&E: Because of the nature of subsurface equipment, vaults and substructures, specific safety rules exist to protect personnel. Because of these rules, subsurface equipment is rarely serviced energized. Pad-mounted or pole-mounted equipment has to be operated first to de-energize the subsurface equipment before servicing or operating any subsurface gear. As a result, planned outages are increased both in size and duration, which adversely affects SDG&E performance based rates to the detriment of ratepayers.

DuPont: As described above, SIDT installations can be designed to permit transformer de-energizing standing away from the equipment and, as a result, the size and duration of outages should not be adversely affected. Furthermore, the SIDT is mechanically robust but for maximum safety we recommend installing primary fuse protection. Transformers can be fused individually on the primary side with an appropriate fused elbow or submersible canister type fuse. Cable limiters, designed for submersible application, can also be applied to protect low voltage service entrance cables from short circuit currents.

The ReliatraN® SIDT features a maintenance-free exterior thermal-plastic shell which has excellent resistance to moisture and corrosion. For application reference, IEEE C57.12.23 Standard for Submersible Single-Phase Transformers: 167 kVA and Smaller; High Voltage 27000 V and Below” Low Voltage 600 V applies, a standard which requires operating limits

of 40 °C average, 50 °C maximum ambient. However, the SIDT can be designed to meet specific customer ambient and loading specifications including installations in non-vented vaults.

Availability

SDG&E: The number of subsurface equipment manufacturers has steadily declined since the inception of this technology. Utilities that once used this equipment in new construction have now begun to move to the pad-mounted standard used by the majority of the electrical industry. Today, only one of the top three transformer manufacturers offers standard submersible equipment.

DuPont: The SIDT represents the first “oil-free” transformer innovation to the Utility industry for distribution applications and currently DuPont is the only supplier. However, the use by Utilities of “solid-dielectric” products is growing, and competitive solid insulation transformer offerings are expected to evolve over time. For example, Cooper Power Systems and G&W Electric developed solid dielectric reclosers back-to-back in the late 1990’s and subsequently have switched most of the Utility industry away from oil-filled reclosers. (Reclosers have two basic functions in the distribution system: reliability and over current protection)

Reliability

SDG&E: Subsurface equipment is highly susceptible to adverse operating conditions. Oil filled equipment needs to have airflow to remove generated heat. Because this equipment is in a confined space, operating temperatures can be multiplied many times. The effects of contaminants and pollutants are increased due to the concentration of these materials in confined spaces. Drainage water collects these compounds and deposits them within the vault spaces. Over time, a rich collection of these contaminants attacks the equipment and increases operational hazards.

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Environment

Submersible Single Phase Transformer in Vault



SDG&E: Hazardous materials collect in subsurface confined spaces and pose an environmental hazard. Like pad-mounted equipment, if there is an oil spill the entire area of contamination needs to be secured and removed by Hazmat Crews. In a confined space or fault, the oil may seep into the ground underneath the vault, and the entire structure will need to be unearthed and the contamination contained and remediated. There is

also an environmental impact with the breeding of mosquitoes in subsurface transformer

installations. For example, in Orange County neighborhood irrigation and watering systems were filling many of our vaults with water. This water, heated by the subsurface equipment, creates a breeding ground for mosquito larvae. City exterminators were called to investigate and address the problem. The chemicals they used increased the caustic environment, further accelerating degradation of the subsurface equipment.

DuPont: Concern about transformer fluids contaminating soil or groundwater is eliminated with the SIDT. We recommend that SIDT units be installed on a bed of gravel in an open bottom vault to reduce water buildup inside the vault.

Expense

SDG&E: The expense of constructing and operating subsurface equipment is 3-4 times greater than pad-mounted equipment, which in turn is more expensive than pole-mounted equipment. Because of the rural electrification act, underground systems have long since been accepted and preferred over the cost effective alternative of overhead distribution. Pad-mounted equipment has become the national preferred method of construction based on years of work and research in the power utility industry. While it was once thought that subsurface equipment would be the next phase in this beautification process, the toll on safety, functionality, and the environment is such an expense that SDG&E and the majority of domestic utilities are not willing to add the cost impacts to their rate base.



Pad-Mounted Single-Phase Transformer

DuPont: With a new technology like SIDT, which remedies past problems, some Utilities are reconsidering offering a total underground installation at a premium to consumers. With a trend to build more expensive homes on smaller building lots, total underground installations substantially improve aesthetics while enabling developers to optimize land use. In addition, the tested sound level of ReliatraN™ SIDT units shows they are much quieter than conventional oil-filled transformers, a property which may be an advantage in high density housing areas.

¹Industry accepted calculations of time and temperature Vs material flexural strength.

²This testing was specified by SCE. Results are available upon request.

³Test report is available upon request.