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Fiberglass: The Next Generation Conduit

Twenty-one reasons heavy industry is abandoning PVC-coated steel conduit in favor of fiberglass for high-performance facility and infrastructure installations.

Executive Summary

Conduit, built to route and safeguard electrical cabling and infrastructure, is often an afterthought when it comes to overall project specification. Conventional conduits are fashioned from a common plastic called Polyvinyl Chloride (PVC), steel or steel that is coated in PVC. In recent decades, project owners, engineers and contractors have sought to optimize project economics, streamline installation and ensure long-term performance, adopting fiberglass conduit for an increasing number of industrial and commercial installations. As hundreds of projects in the field have revealed, this modification in material specification has resulted in a significant overall impact to project and facility economics.

Conduit's Overall Impact on Project Economics

We've examined whether a stakeholder should care about which conduit is specified, since it's often a smaller percentage of the budget. When you look at the CAPEX budget and scale of your average industrial facility or infrastructure project, conduit impacts project economics in the following ways:

- Ensuring the facility or infrastructure will perform well long-term
- Allowing engineers to draft more flexible, efficient and cost-effective designs
- Streamlining the project's implementation and ability to meet milestones
- Protecting project stakeholders from future safety risk exposure
- Protecting project stakeholders from future environmental risk

This paper will discuss a number of positive impacts that are made when an engineer or other project stakeholder specifies fiberglass conduit. In the end, they all fall into one of the above five value categories. Aggregately, these various points of conduit's economic and operational impact have been proven to represent millions of dollars in potential economic value.



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To validate the point that conduit impacts a project's bottom line; consider the design efficiencies enabled by choosing conduit. Fiberglass exhibits a very high tensile strength relative to its lighter weight. Because of this attribute, for example, the design engineers at a leading East Coast lignite power generation facility were able to pull the conduit for longer distances than they would have with the originally specified conduit. As a result, they were able to save a conservative estimate of \$1.5M by eliminating a number of needed access points (which are expensive to build). This is serious value that can be unlocked by project stakeholders, simply by specifying a smarter conduit material. And this only represents one aspect of this leading-edge material's value profile.

The Fiberglass Advantage in Detail

The demand for fiberglass conduit in the United States alone has been growing significantly over the last two decades—and is forecasted to increase further as project owners and engineers seek to serve long-term interests of their stakeholders. Let's look in detail at why fiberglass conduit is gaining so much ground against materials such as PVC-coated rigid steel conduit.

1. Total Installed Longevity

The lifespan of a PVC-coated rigid steel conduit in a heavy industrial environment can be as short as two years—depending on the specific application. This is due mainly to its limited corrosion resistance. But fiberglass conduit can be engineered specifically to resist corrosion and other environmental and operational challenges to last as long as three-times the lifespan of PVC-coated rigid steel conduit in serving applications such as wastewater treatment, underground infrastructure, process manufacturing or oil and gas facilities.

2. Faster Installation Time

Installing PVC-coated pipe, which requires bending it to design specifications, requires special tools not typically on hand for a contractor in the field. It's also exceptionally heavy—approximately four times the weight of comparably sized fiberglass conduit. Given the amount of conduit inherent in most projects, this translates into a significant amount of potential risk and burden to project deadlines (as well as much bigger crews). Also, fiberglass conduit is fashioned using a common PVC "hot box" which most contractors typically have on hand in the field.

3. Less Expensive Installation Costs

Because installing PVC-coated rigid steel conduit is more difficult than installing fiberglass conduit, the subsequent labor rates are accordingly higher for installation. The National Electrical Contractors Association (NECA) labor rates for a normal 100-foot installation of 5-inch pipe would be around \$8.60 to install fiberglass conduit versus an installation labor rate of \$45 for PVC-coated rigid steel conduit. Similarly, labor rates for a parallel purchase of 1-inch fiberglass versus PVC-coated rigid steel conduit would be \$5.75 and \$10, respectively. This level of savings can make a significant impact on owner and engineer budgets, as well as contractor operating margins.



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4. **Burn-Through and Overall Coefficient of Friction**

Burn-through occurs when pulling cabling through the conduit heats up the conduit wall and damages the conduit's structural integrity through the application of friction. This results in conduit failure and an unsafe operating condition. Both fiberglass and PVC-coated rigid steel conduit resist burn through well. However, fiberglass conduit exhibits a better coefficient of friction than PVC-coated rigid steel (.38 vs. .55). This means a faster, smoother pull with less time, cost and risk. In addition, fiberglass conduit is less susceptible to damage from the various types of pull-through lubricants common in the industry.

5. **A Superior Range of Corrosion Resistance**

Corrosion dynamics are unique to every environment. There are some rare environments wherein PVC-coated rigid steel conduit may be the most resistant to corrosion—including operations with exposure to large amounts of liquid ammonia, hydrofluoric acid or methyl ethyl ketone. But generally fiberglass conduit is engineered to offer the widest range of corrosion protection of any conduit material available on the market today—resistant to exposure to hundreds of types of chemicals and a range of operating temperatures. PVC-coated steel offers only a limited range of performance in terms of corrosion resistance. That's why it's seen use in applications such as wastewater treatment, hydrocarbon processing or mining and enduring intensive exposure to such toxic elements such as acetic acid, hydrochloric acid, glycerin, gasoline, lime slurry, lithium chloride and naphtha.

6. **Superior Shape Retention**

In terms of shape, fiberglass is shown to retain its form after impact or compression—more so than several other options—offering the strength and flexibility to stand up to a range of conditions, such as earthquakes or other extreme environments. By comparison, PVC-coated rigid steel conduit is much more easily damaged because of its PVC component.

7. **Customizable Material Properties**

Fiberglass conduit is made by winding the fiberglass fibers into the an epoxy resin, so this base resin material can be customized in terms of composition to exhibit specific performance capabilities or attributes that optimize its performance for a particular application. For example, different types of resins can be used to tweak the conduit's corrosion resistance capabilities. Also, materials such as graphite can be added to the resin mixture to make the fiberglass conduit shielded to electromagnetic and radio frequency interference (especially useful in the medical industry, specialty communications applications, etc).

8. **Ambient Thermal Expansion**

The temperature of the operating environment can cause conduit to expand or contract slightly with changes in thermal dynamics. This is true of all modern conduit materials (and, in fact, almost all materials period). Fiberglass conduit expands more than PVC-



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coated rigid steel conduit when exposed to extreme changes in temperature. But this thermal flexibility is part of its true strength as an applied material—and what makes it so easy to work with in the field (i.e., being easily shaped with a PVC “hot box.”) And the effects of the expansion are rarely an issue, as your average fiberglass expansion joints allow up to 15 inches of play each. For every 100 degree of change in temperature, fiberglass conduit expands 1.8 inches. So an expansion joint for every straight run of conduit manages any potential risks from thermal expansion and still gives you a material you can shape on the fly (changes to the shape of PVC-coated rigid steel conduit must be typically made off site).

9. **Conductivity and Safety Performance**

Fiberglass conduit does not conduct electricity, as PVC-coated rigid steel conduit does. Instead, it serves as an electrical insulator. This means improved safety performance, as electrical faults within the conduit will not turn the entire conduit itself into a potentially fatal safety risk. Touching a PVC-coated rigid steel conduit with a wiring fault in the wrong spot can be deadly. Over 500 contractors each year die from preventable electrical shocks, and over 300,000 experience non-fatal shocks at the jobsite. Specifying fiberglass conduit can give a crew greater peace of mind, enable engineers to design safer facilities and infrastructure—and allow project owners to protect themselves from both the risk of on-site accidents and the expensive litigation that goes with them (average at-work electrocution lawsuit averages between \$1M-\$4M USD).

10. **Less Overall Product Weight**

Though proven very strong and durable in the field for decades, fiberglass conduit weighs much less than PVC-coated rigid steel conduit. This means less structural burden on supporting structures, less material/hardware, lower labor and installation cost—as well as more design efficiency and flexibility. For example, a 100-foot-long piece of fiberglass conduit that is one inch in diameter would weigh around 27 pounds. A similar length of PVC-coated rigid steel conduit pipe would weigh over 150 pounds. And the differences in weight for a similarly cut piece of 5-inch conduit would be 97 pounds vs. 1,344 pounds, respectively.

11. **Lower Materials Toxicity**

Despite the best efforts of engineers, project owners and contractors—accidents happen. And when they do, you don't need the added potential safety, environmental and legal risk of electrical conduit that releases toxic halogens into the environment. Conduits composed of any type of PVC material, whether PVC or PVC-coated rigid steel, release toxins such as chlorine and bromine into the environment when burned. Both of these elements present an immediate danger to facility employees, the public and first responders. Chlorine, even in moderate amounts, can affect the central nervous system and respiratory system. Bromine is used as a pesticide and can cause long-term health problems. If worse comes to worse, the burning of fiberglass conduit is halogen-free, so the immediate work area or environment is spared from associated toxicity. In the most



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recent report by the National Fire Protection Association, more than 42,000 industrial facility fires are reported in the United States annually—averaging 22 deaths, 300 injuries and \$951M in property damage.

12. Lower Total Installed Cost

Per-unit materials cost for PVC-coated rigid steel alone are very competitive, but once you factor in the cost relative to labor—your actual relative installed cost—PVC-coated rigid steel conduit can cost up to FIVE TIMES MORE than fiberglass conduit. Because fiberglass conduit demands a lower labor rate of installation, is easier to handle in the field, requires fewer people to install and lasts longer due to its superior durability—the overall cost of installed conduit over time is typically much lower than PVC-coated rigid steel pipe. In addition, the infrastructure and hardware hosting the conduit can be less intensive because of fiberglass conduit's light weight. Factoring in the additional longevity allowed by its superior resistance to various types of corrosion, UV rays, and other properties owing to its durability and the overall improvement in return are made exponential.

13. Relatively Easy Materials Re-Use

Change is a natural part of a facility's lifecycle. One common situation that many project owners, engineers and contractors face is the prospect of being able to use conduit that's already in place when upgrading, retrofitting, decommissioning or making other changes. Fiberglass conduit can be reused for similar services merely by cutting out the coupled areas and introducing new fiberglass coupling. By contrast, it's difficult to practically reuse PVC-coated rigid steel coupling. This is for two reasons: first, its unwieldy weight and labor-intensive nature means that it is difficult to handle without damaging the conduit's PVC coating and rendering it sub-optimal. Second, once installed PVC-coated rigid steel conduit tends to rust so that the couplings are all seized in place—requiring cutting and difficult manipulation in the field.

14. Smooth and Gapless Connections

Lengths of PVC-coated rigid steel conduit connect to themselves differently than lengths of fiberglass conduit do. If you look at the cutaway of a joint combining two pieces of PVC-coated rigid steel conduit, you'll notice a physical air gap between the actual pieces within the center of the connection. Though present in many installations around the country, these gaps within the connection represent a real risk of cable damage—leaving the conduit's interior exposed and vulnerable. Fiberglass conduit is connected either mechanically snuggling together (as with underground applications) or connected using high-tech adhesives optimized for the conduit's specific operating environment. Either way, the result is a smooth and gapless connection that bonds with more than enough strength and leaves no gaps in the connecting conduit. Fiberglass conduit gives your cabling a smooth ride, no matter which direction it was pulled, as it runs from connected lengths of pipe without interruption.



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15. Superior Vibration Resistance

If you've ever walked across a large bridge like the Brooklyn Bridge or the Golden Gate Bridge, you can feel the non-stop vibrations that the structure experiences during its life of service. Because of its superior resistance to vibration, combined with its high strength-to-weight ratio, fiberglass conduit is a popular choice for bridge applications (such as the Tappan Zee Bridge, which crosses New York's Hudson River at one of its widest points). And this vibration resistance translates into superior services in the utility, energy, process-intensive manufacturing and other industrial applications.

16. Simplified Field Handling and Logistics

This benefit is especially germane to contractors, but also relevant to project owners. Once on-site, the installation of fiberglass conduit is a much simpler affair than installing PVC-coated rigid steel. You need a fraction of the people, less equipment, more easily available equipment and much less time to do the job overall. When considered altogether, this streamlines the installation of your project's conduit overall—meaning a better margin for contractors, more confidence in project timelines for project owners and a safer working environment (with less people, trucks, etc getting in the way) for everyone.

17. Superior Engineering Design Flexibility

Because of its aforementioned qualities of being lightweight yet strong, needing few structural supports and its resistance to corrosion, vibration, sunlight and other environmental and operational challenges—engineers have more design flexibility with fiberglass conduit. Fewer access points for underground installations, less weight burden on the overall structure, fewer concerns about long-term damage and other benefits mean that engineers have more freedom to pursue their big-picture vision with fewer conduit-related constraints.

18. Strong Mechanical Memory and Durability

For those who haven't held or felt fiberglass conduit, it is a strong and rigid product—and it can take a beating. Specifically, a fiberglass conduit of standard wall thickness (around .70 inches) can absorb a mechanical impact, compressing and flexing back to its original shape without impacting its serviceability. Fiberglass conduit with an especially heavy wall thickness (say, .25 inches) shows absolutely no effect from a reasonable mechanical impact. By contrast, PVC-coated rigid steel does not snap back and is made inoperable by a mechanical impact. Not only does the steel not snap back from an impact but the exterior PVC coating is easily damaged. Touch up repairs can be made to the exterior of PVC-coated rigid steel conduit out in the field, but generally these repairs are less effective because once damaged the chemical bond between the PVC coating and the steel conduit has been permanently damaged.



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19. Life After an Electrical Fault

If you discover an electrical fault within a PVC-coated rigid steel conduit, that conduit is then deemed useless and no longer suitable for service in the field. The conduit must be removed and replaced. This is also the case with standard PVC conduit. But faults within fiberglass conduit do not affect the conduit's potential for future performance. You only need to find and fix the fault—no removal or replacement is required. This can be a considerable savings of cost and help keep the facility online for its entirety.

20. Fast, On-Demand Manufacturing

Oftentimes fiberglass conduit can be manufactured in the time it takes to merely get a quote back from your standard provider of PVC-coated rigid steel conduit. This is because each piece of conduit can be made quickly, on-demand—simply winding a proprietary woven fiberglass pattern into the resin housing at the desired specification. There are simply fewer steps to the process, and this typically translates to their manufacturing process in general being around 20-30 percent faster than comparable PVC-coated rigid steel conduit.

21. Smoother Interior Surfacing

Because of the dynamics of standard steel manufacturing processes (this conduit is welded from the interior) the inside of PVC-coated rigid steel conduit can sometimes contain a weld scarf or thin edge made of metal. If this sharp edge is present in the conduit, when cable is pulled through the conduit it is permanently destroyed. Fiberglass conduit is wound on a steel mandrel and offers no potential for damaging imperfections in the conduit's interior so there is no risk of pull-through damage.

Proven in the Field for Over 40 Years

As this article has shown, fiberglass is a proven solution in a number of high-profile projects, from the Niagara Falls Observatory to the Freedom Tower in New York City. It's proved to withstand caustic wastewater treatment facilities, extreme mining projects and the high-saline environment of the Intrepid Potash—among several others.

Interested in learning more? To see all the ways Champion Fiberglass can help save both time and money on your projects, while ensuring better all-around performance, visit www.championfiberglass.com

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