# Best Practices to Follow for VFD Cable Installation

WHITE PAPER

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## Executive Summary

The demand for variable frequency drives (VFDs) is increasing for several reasons: they provide better motor control, improve energy efficiency, reduce machine maintenance, decrease operating costs, and extend equipment lifecycles.Proper cable application can help you avoid costly downtime, equipment degradation and frequent unnecessary maintenance. A crucial aspect of the cable-selection process is deciding between grounding cable glands and isolating cable glands. Grounding glands, while useful in specific scenarios, can pose risks such as noise leakage and the formation of common mode current loops (CMCs), which can lead to costly, premature motor bearing wear and disrupt sensitive equipment, potentially compromising overall system performance. In contrast, isolating glands are the preferred choice. They maintain the integrity of the cable shield, effectively reduce electrical interference and contribute to the extended lifespan of critical equipment.

By investing in high-quality cables and selecting the appropriate cable glands, you can maximize return on investment and minimize operational disruption. This ensures the long-term reliability and efficiency of your company's automated systems.

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## Introduction

Demand for variable frequency drives (VFDs) is on the rise for many reasons. Because they offer better motor control, they can help improve energy efficiency, reduce machine maintenance, decrease operating costs and extend equipment lifecycle.

With this persistent demand for VFDs, it has become increasingly important to understand how to properly specify, install and terminate VFD cables. These adaptable cables provide enhanced precision and control over motor speed and torque, offering significant operational benefits. To fully leverage these advantages, end users must be properly trained and informed about correct cable application practices.

A crucial aspect of VFD cable selection is deciding between grounding cable glands and isolating cable glands.

**Grounding glands,** while useful in specific scenarios, can pose risks like noise leakage and the formation of common mode current (CMC) loops, which interfere with performance. For example, CMC loops can lead to costly and premature motor bearing wear, which disrupts sensitive equipment and could compromise overall system performance.

In contrast, **isolating glands** are the preferred choice because they:

- **Maintain the integrity of the cable shield**
- **Effectively reduce electrical interference**
- **Contribute to the extended lifespan of critical equipment**
- **Are more economically feasible than ground-terminating glands**
- **Require less labor to install**
- **Don't need termination kits**

By investing in high-quality VFD cables and selecting the appropriate cable glands, you can maximize return on investment and minimize operational disruption. This ensures integrity by reducing damaging CMC loops, protecting motors against reflected wave voltages, reducing cable charging currents and providing safe and reliable long-term operation of equipment.

To receive these benefits, proper termination and gland selection is imperative. In this white paper, we'll discuss:

- Why VFD cables are necessary
- Where VFD cables are used
- How to select the right VFD cables
- How to terminate VFD cables
- Key considerations for cable gland selection and when to use them

## Why VFD Cables Are Necessary

Noise and interruptions are inevitable in industrial environments. VFD cables are specifically designed to withstand these harsh conditions, ensuring that harmful VFD noise currents do not interfere with operations. This is achieved through the use of large grounding conductors and effective shielding, which capture noise and safely carry it to the source (the drive where they originate) for dissipation.

The effectiveness of this process is compromised if the cable is improperly grounded or terminated—particularly when CMCs are present and the cable is exposed at termination points with shield-terminating grounding glands. Electrically, grounding the shield at intermediate points makes the system more like a pipe and wire installation, potentially undoing the noise isolation benefits of the VFD cable. Using grounding glands requires the shield to be terminated at each gland. This not only disrupts shield and ground continuity and exposes sensitive equipment to electromagnetic interference (EMI), but also creates vulnerability for CMCs to affect the overall system.

The release of noise currents poses significant risks to motor bearings, and sensitive equipment like PLCs could be disrupted by EMI.

Furthermore, when a motor disconnect is used, grounding glands at the disconnect can create a ground loop through the motor bearings that would result in reduced motor bearing life. As currents follow the path of least resistance, bearings often become the target, leading to accelerated wear and tear. This current slowly damages motor bearings and eventually leads to failure. To ensure the longevity and reliability of your automated systems, it's crucial to take precautionary measures now to protect your investment and maximizereturns, particularly for high-value equipment.

**What is VFD termination?**

VFD termination refers to the process of properly connecting a cable to a Variable Frequency Drive (VFD). This involves securely attaching the cable to the VFD, ensuring a reliable electrical connection. The termination process requires a variety of tools to strip the cable jacket, position the conductors and fasten the cable into the drive. Proper termination is crucial for optimal VFD performance and the longevity of the system.

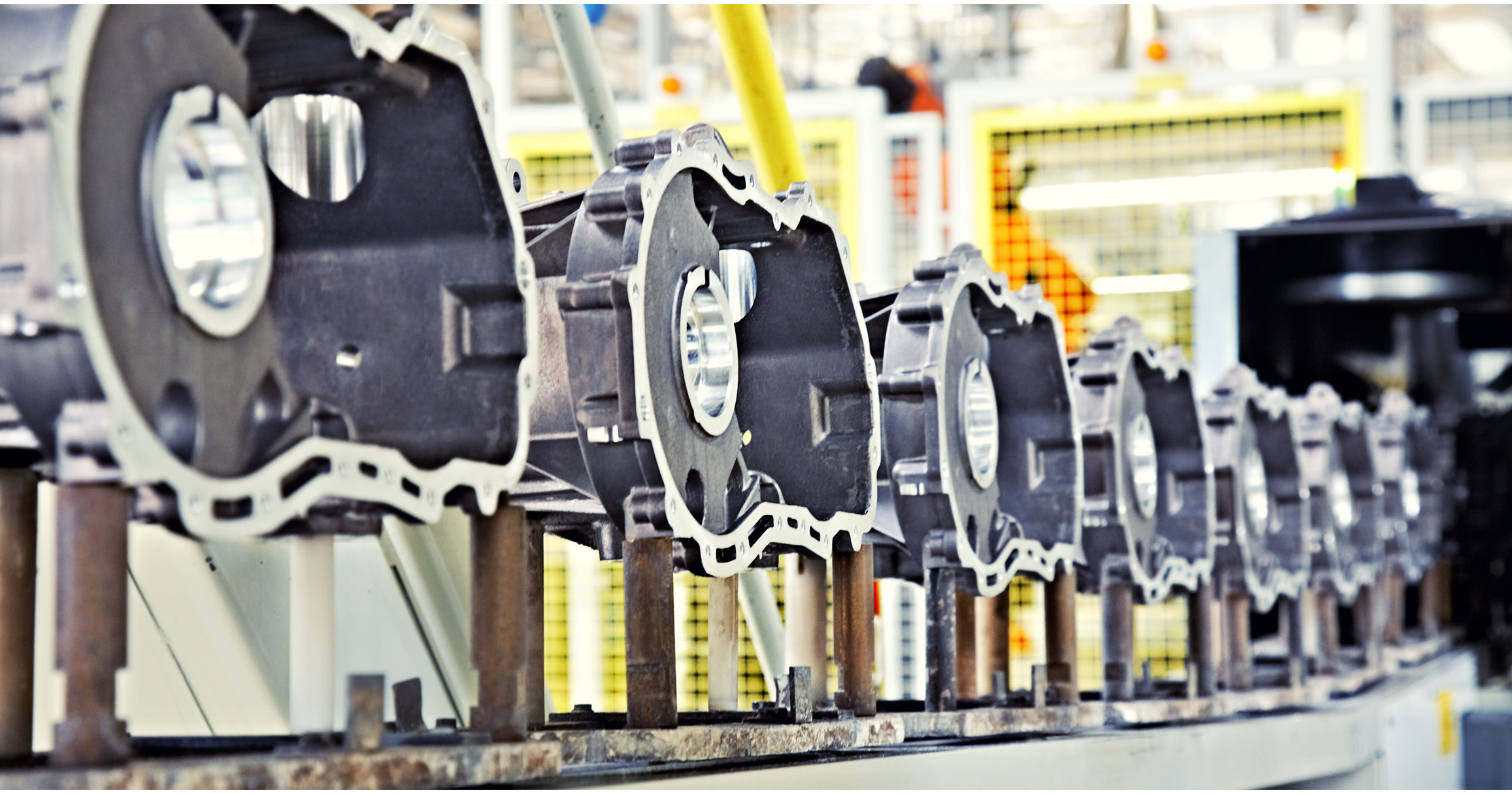
## Why Proper Specification of VFD Cables Is Important

If you want to save time, money and effort while protecting significant machinery investments, then using high-quality cables must be used in the right way to significantly reduce the risk of wear and failures. Proper cable specifications, effective shielding, and robust, finely stranded grounds all play a vital role in maintaining equipment reliability and longevity.

On the other hand, improper VFD cable specification not only jeopardizes immediate operation but also negatively affects the longevity and performance of connected motors and machinery. These mistakes can compromise output quality and pose safety risks to end users due to potential damage and faults in the overarching system. Faulty termination can add noise to the grounding system, leading to increased electrical interference across the system. As a result, downtime may increase, and the reliability and efficiency of the entire operation can be significantly compromised. The selection of THHN-type conductors leads to higher cable losses, more reflective wave voltage and the potential for more bearing currents, as well as premature cable failure.

Properly specified VFD cable terminations are critical to ensure that noise currents, such as ground and bearing currents, don't adversely impact system performance. Incorrect equipment specification or selection, such as using a shield-terminating or grounding gland when shielding isolation from the ground is necessary, can lead to damaging CMC loops. It can also result in induced ground currents, which disrupt machinery communication and interfere with nearby devices, such as radios, wireless networks, sensors and instruments.

While grounding glands may be suitable for certain applications, Belden generally recommends the use of isolating glands to avoid issues like ground loops and ensure stable, interference-free operation.



## Grounding Glands vs. Isolating Glands

Cable gland selection is often the final crucial step in completing your solution.

When choosing between a shield-terminating grounding gland and a non-conductive isolating gland, it's vital to understand their differences, which can make or break your automation system. A grounding gland terminates the shield and grounds at each point of use. The cables are inherently inclined to create common mode current paths. Inside the gland, a spring mechanism typically conducts ground currents and ground noise, passing them to the sheet metal for dissipation. However, this method has a significant drawback: The VFD cable's shield is stripped, and the cable is directly attached to machinery. This can create potential noise current leakage from unshielded cables closest to the most sensitive equipment.

This can negatively impact nearby equipment. Furthermore, the grounding of the cable makes it susceptible to additional noise, which travels through the shielding and grounding to cause bearing wear and tear or releasing noise currents that can interfere with other equipment. Because of the attachment to the ground and the shield termination that grounding glands require, this process riskier and more likely to create noise issues. Grounding glands are more expensive, more complicated and more likely to create issues compared to an isolating cable gland.

In contrast, isolated cable glands preserve shield integrity, isolating and separating the VFD cable from the machinery surface. This approach optimizes the flow of common mode currents inside the cable and reduces the flow of common mode currents outside the cable where they may cause harm to motor bearings and other sensitive equipment. In addition, because the cable remains isolated and is directly attached to the drive, connections are clean, secure and interference-free. If the shield remains intact to the drive, then no termination kit is necessary. This protects equipment while reducing the risk of interference.

By choosing isolating glands, you invest in the long-term reliability and efficiency of your automated system, safeguarding your equipment and ensuring optimal performance.

## When to Use a Shield-Terminating Grounding Gland

Belden designs and manufactures VFD cables to ensure continuous contact between the shield and grounds. Because of this design feature, the shields are effectively terminated by terminating the ground. If a VFD cable manufacturer is not diligent in ensuring the continuous contact of the shield and grounds, then a shield terminating gland might be necessary for safety.  If you opt to use a shield-terminating gland, be sure it has the necessary rating and is UL Listed for the cable type in use.

## When to Use an Isolating Cable Gland

Belden recommends isolating glands as the preferred method. Isolating glands effectively seal and isolate the cable ground through the cable jacket and carry ratings based on industry standards. Isolating glands prevent the release of harmful noise currents, such as CMCs, in the shields and grounds. By isolating these currents, isolating glands help:

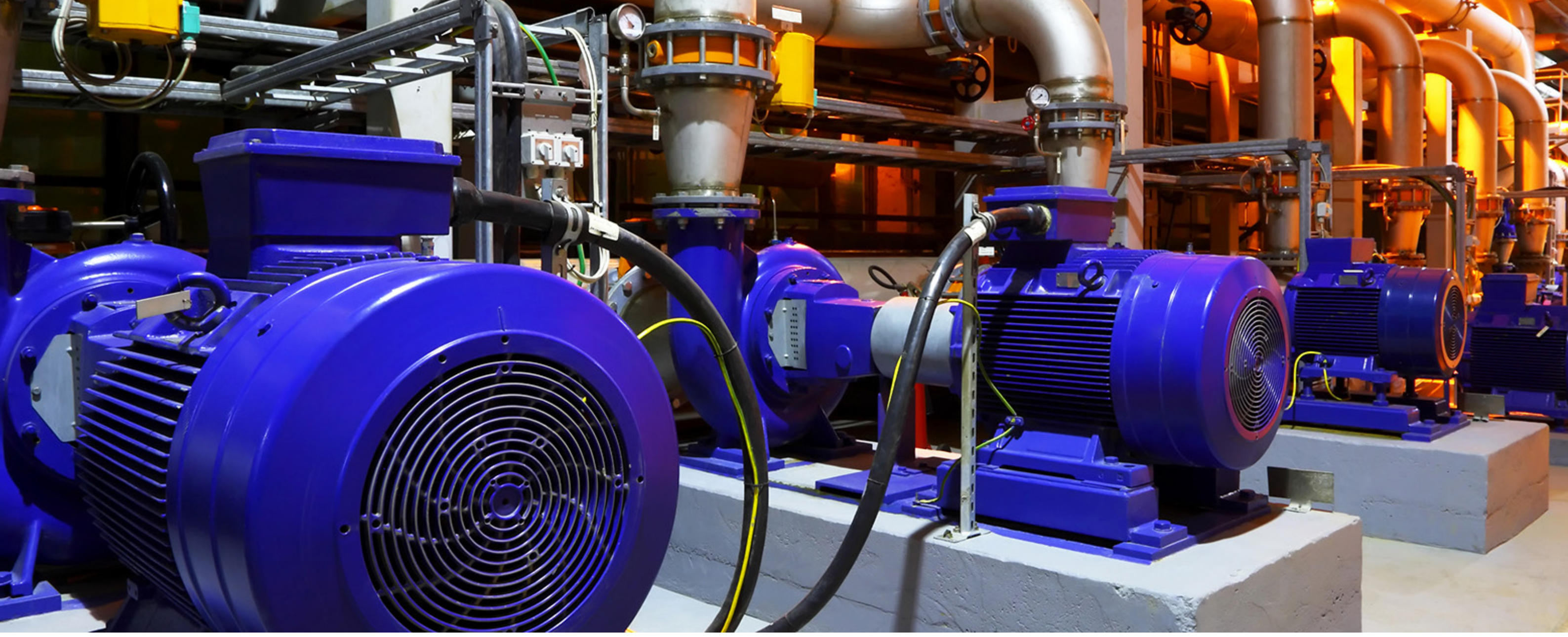
- Maintain electrical system integrity
- Reduce the risk of interference
- Extend the lifespan of connected equipment
- Minimize the potential for bearing currents that lead to premature wear and failure of motor bearingsProvide the necessary sealing required for hazardous locations and reduce the risk of ingress

Isolating glands take a proactive approach to managing electrical noise and safeguarding sensitive components in industrial environments. For this reason, they're typically the preferred solution. They offer benefits similar to grounding glands while preserving the integrity of the cable.

### Use of Motor Disconnects

It's important to route the cable through any disconnect box to the motor to ensure that the ground and shield are both uninterrupted and isolated. This removes the likelihood of releasing CMCs and generating damaging bearing currents.

Grounded shields increase bearing current loops due to the CMC loop created by the grounding glands.



## What to Look for When Choosing Isolating Cable Glands

Incorrect cable and gland selection can lead to excessive expenses associated with bearings and other critical equipment.

It's important to use UL-approved glands that are specified for the application, particularly those for Class 1, Div 2 environments. Be cautious of glands that lack a UL E-file reference number: They may not meet safety and performance standards.

Improperly selected VFD glands can emit noise from ground contact and may result in suboptimal grounding. Grounding glands may also require the complicated use of a termination kit, a poor solution that should be avoided. This may also leave unshielded cables inside enclosures, exposing sensitive equipment to EMI.

## Selecting a Cable Gland

It is always important to understand the connection and application of your cable. It can be the difference between a reliable, long-term operation and a system in need of regular maintenance.

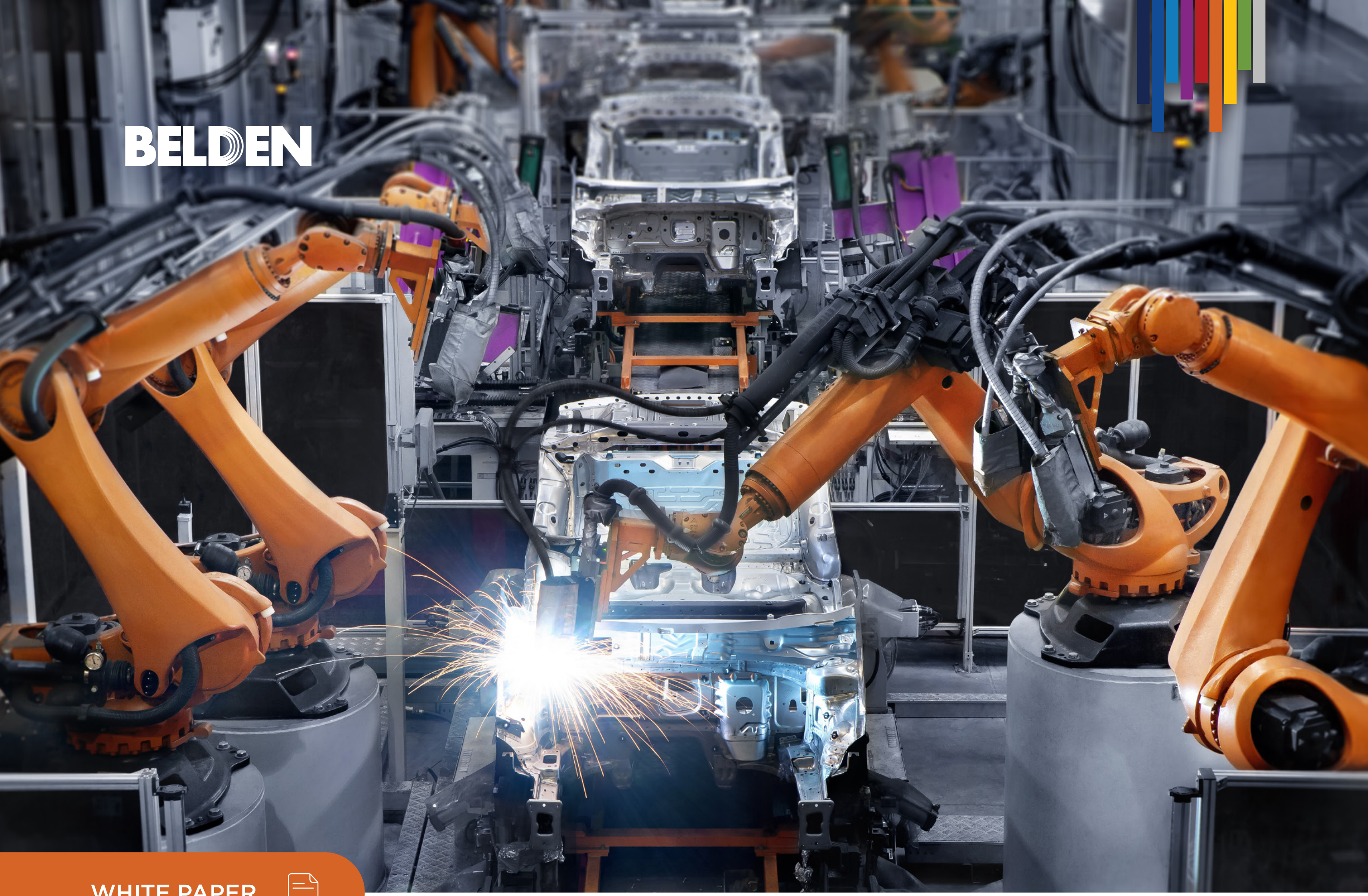
Belden makes it simple for you to select the best isolated gland by providing our **VFD Design Series: Belden Gland Cross Reference**.

For additional resources,
please check out our VFD series:

**VFD Design Series: What Makes it VFD Cable?**
**VFD Design Series: 100% Ground**
**VFD Design Series 300% Ground**
**VFD Design Series: Signal Pair**

### Why Termination Kits Aren't Necessary

When termination utilizes isolating glands there is no need for the additional expense and complication of termination kits. Specifiers may often feel inclined to use a termination kit when completing cable terminations. This is usually unnecessary. Termination kits are typically required only to address issues that arise from incorrect gland specifications. By choosing the correct glands from the start, cables can perform to their intended specifications without the additional expense and installation complexity of a termination kit. Check out **VFD Design Series: Termination Kits** to learn more.

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