The Fundamentals of How to

Properly Spec a Monolithic Isolation Joint

(for oil and gas)

GPT Industries

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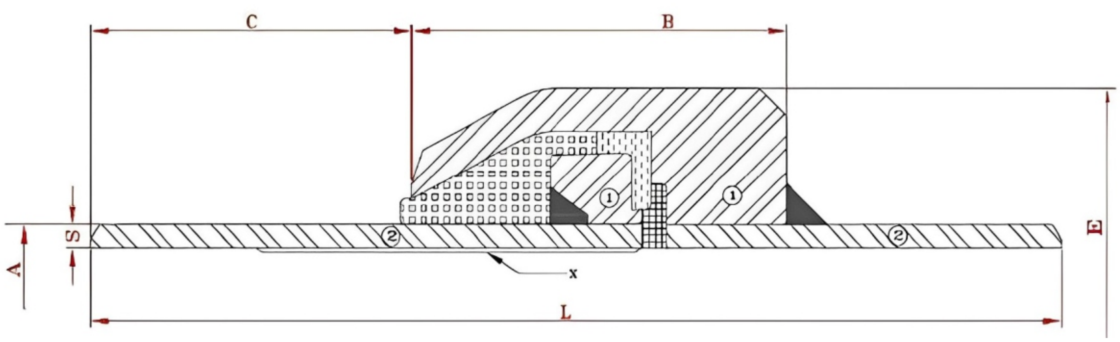
Introduction

An MIJ (Monolithic Isolation Joint) is comprised of several key components. In this paper we will take a deep dive into each component that makes up an MIJ in an effort to provide the information and context that is necessary to properly specify an MIJ, either for your project or for your company as a whole.

It will help serve as a buyer's guide to MIJs. We will discuss scenarios and different variables that impact the requirements of the MIJ in your system and provide suggestions on how to approach them to optimize the performance of your CP (Cathodic Protection) System and your pipeline health overall.

The first section will focus on available MIJ designs and the recommended application to use them in. Please note that the key difference between MIJ designs has to do with the seal design/method and the assembly process.

L shape seal in a mechanical closure design:



Ideal for sweet natural gas applications ranging from ½ inch to 8” up to 600# class (excluding 8” 600#). This design offers a simple and repeatable process for manufacturing which allows for a high-quality product to be made specifically for small gas distribution and gas service lines, economically.

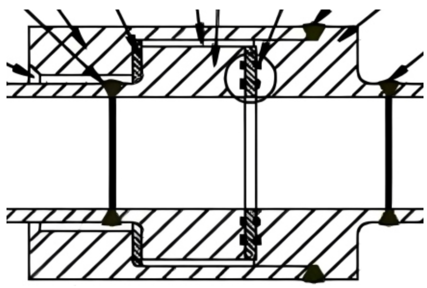
This design eliminates the need for a closure weld that tends to create problems in small diameter MIJs, due to excessive heat in proximity to the internal components during welding. In this design, the closure flange is mechanically pressed and formed to compress the internal components and create the desired seal.

U shape seal in a welded closure design:

Ideal for medium to high pressure applications of all sizes. The U seal design offers a sealing methodology that fully encapsulates the isolating ring that will be exposed to the pipeline media. This is important for medium and higher-pressure applications up to and exceeding the 1500# class.

Even if the isolating ring is permeated or compromised in such a way that would normally make it ineffective as an isolating joint, the U seal eliminates any chance at a metallic path within the body of the MIJ. While welded designs are typically at risk of overheating internal components during manufacturing, they are much stronger than the mechanical closure designs and can withstand the rigors of these higher-pressure applications with ease.

U shape seal in a welded closure design:



This is the most widely available design in the market, and it can be used to build MIJs from 2" to 100" + applications of all pressure classes. It is a versatile design that makes for easy customization of isolating and sealing components to accommodate a wide range of pipeline medias and temperatures etc. When done correctly, this design can be used for the most challenging MIJ applications in the world.

The important thing to remember when purchasing a welded closure design MIJ is that the manufacturer must know that the internal components are both rated for the temperatures they will see during the closure weld process and designed in such a way that there is enough distance between the site of the weld and the position of the internal components to avoid damaging the integrity of the joint during assembly. This along, with well-regulated welding procedures, will ensure that the welded closure designs are built with integrity.

A quality MIJ manufacturer should be able to verify this with design validation calculations and material certificates. In the next section, the focus will be on the steel components and the best practices associated with specifying these components to get the longest life possible out of the MIJ you are looking to buy.

All Steel Flanges and Steel Pipe Used in Construction of MIJs

When determining the appropriate specification requirements for steel flanges and pipes used in MIJ construction, it is important to prioritize your needs based on potential risk. In our experience, the primary sources of risk associated with buying steel flanges and pipe are as follows: raw ingot origin (melt), forming process (make), material standard (metallurgical controls) and the final inspection/acceptance criteria (QMS).

By strictly controlling the melt, make, metallurgy and QMS that is in place you can mitigate much if not all the risk in sourcing steel components. This will refine the number of suppliers you are able to accept down to those who make integrity their highest priority.

Construction Checklist

- Shall only be sourced from vendors with an approved quality management system (ISO cert at a minimum
- Forging maker must source ingot from verified producers via third party testing such as a 3.2 if they are not aproven ingot supplier.
- Ring rolling or casting process should take place in G7 countries.
- Machining should be controlled by tight controls through verified drawings with tolerances available.
- Traceability to raw ingot source must be available for each component upon request.
- Wetted steel components shall be compliant with NACE MR0175 for all services where sour conditions may exist over the design life of the pipeline system.
- Seamless pipes are preferred whenever possible. Typically, it is only available up to 20" NPS. For all welded pipes, ensure the methodology for welding is in line with your standards and request inspection reports for the NDT of the welded pipe.
- Material Grade vs. Carbon equivalent, typically, CE% increases as Material Grade increases but good forge and casting shops with quality ingot can mitigate this problem with highly controlled processes during the production processes. High CE leads to brittleness and can drastically reduce the ability for the MIJ to withstand impact/bending moments etc.
- Machining tolerances become most critical along the ID of the MIJ to ensure a perfectly aligned bore through the joint. This helps to minimize the potential for contaminants to build up on the ID of the isolating component and also minimizes flow interruptions.
- The closest possible match from MIJ pipe pup to the application line pipe provides the highest likelihood of achieving a quality weld during install in the field. It also ensures that any design calculations done for the pipe are mirrored by the MIJ. Typically, this will also eliminate the need for welder qualification or procedural qualification for the installer as the pipe pup material will match the line pipe material.

Selecting Isolating Material and Component Design

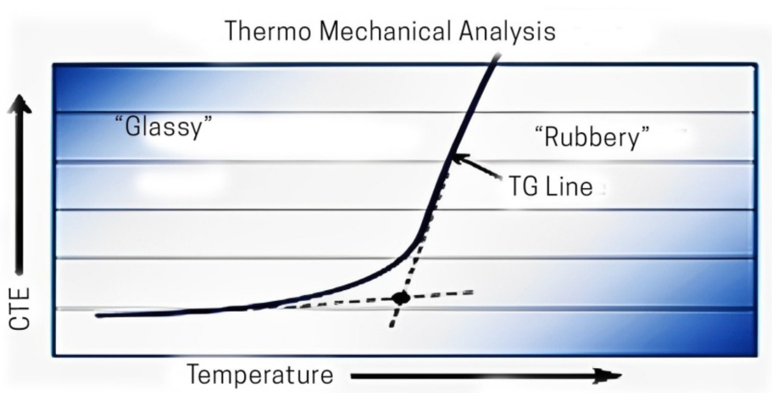
This section will cover the importance of selecting the right isolating material and isolating component design.

Isolating Element

The challenge with specifying the isolating material for an MIJ is that there are so many options that all seem to be the same on paper. If you specify G11 or G10 for example, that is a material grade that implies a certain dielectric strength, resistance, and temperature compatibility. The problem is that the individual batches of sheet material that are used to make these gaskets are not tested to verify the performance before the sheet manufacturer ships them out to be cut into gaskets. A lab test or an MTR for gasket materials is the safest bet to verify a given sheet was produced to the desired specification.

When considering which isolating material is best for your MIJ application, it is always best to consider these factors:

- Temperature rating.
- Chemical compatibility .
- Dimensions.
- Water absorption.
- Dielectric Strength.



Material NEMA LI-1	Glass Transition Temperature (tg) °c (°F)
G10	115 (239)
G11	180 (356)
FR4	130 (266)
G400	210 (410)

Elastomeric Seal

The first thought when it comes to specifying elastomeric sealing materials for an MIJ is usually media compatibility. There are additional things that must also be considered. For example, nitrile is great in most oil and gas applications in terms of chemical compatibility and operating temps, however the issue is that these components see higher temps during assembly of the MIJ than they do in service. Welding in proximity to these components generates a significant amount of heat. This heat can linger in the steel for extended periods of time. With a low max temp like 260F that is common for nitrile, there is a high risk that these components could be damaged during production, which is almost impossible to confirm without cutting apart a complete MIJ. Viton offers the same chemical compatibility but at a temperature of 400F, that, coupled with temperature controls during welding, will give a safe buffer to ensure the internal components are not damaged.

When considering which sealing material is best for your MIJ application, it is always best to consider these factors:

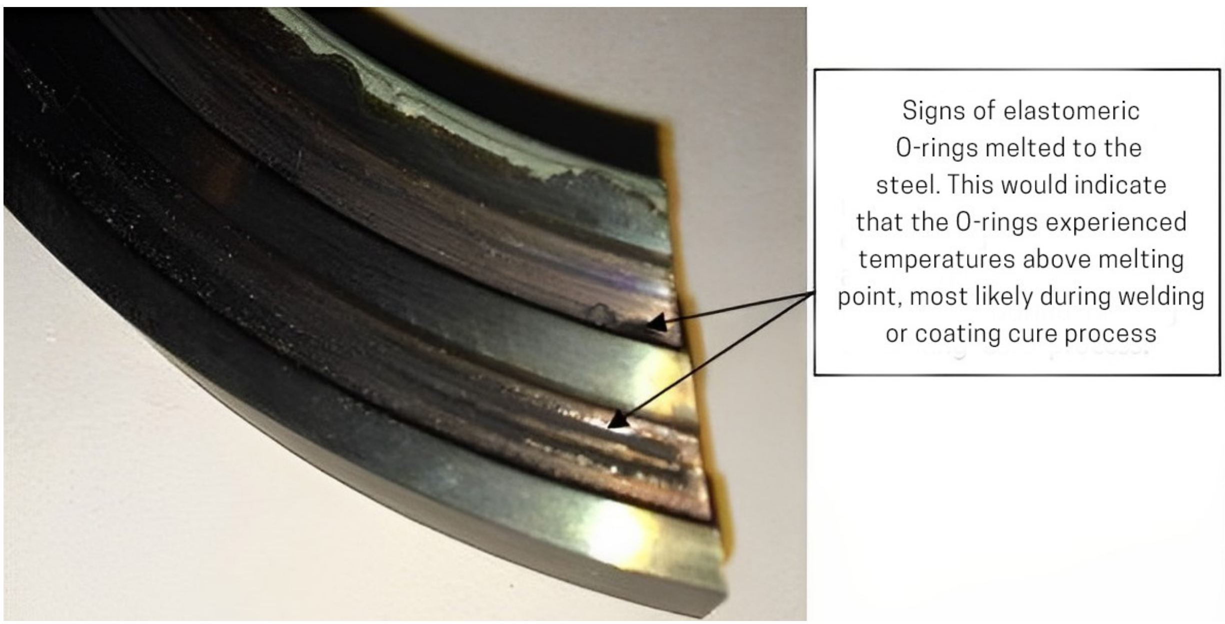
- Temperature.
- Chemical compatibility/Media composition.
- Explosive decompression properties.

Differences in Fluid Resistance Between Types of Viton® Fluoroelastomer

	Type of Viton® Fluoroelastomer							
	A	B	F	GBL-S	GF-S	GLT-S	GFLT-S	ETP-S
	Cure System							
	Bisphenol			Peroxide				
Hydrocarbon Automotive, Aviation Fuels	1	1	1	1	1	1	1	1
Oxygenated Automotive Fuels (containing MeOH, EtOH, MTBE, etc.)	NR	2	1	2	1	NR	1	1
Reciprocating Engine Lubricating Oils (SE-SF Grades)	2	1	1	1	1	1	1	1
Reciprocating Engine Lubricating Oils (SG-SH Grades)	3	2	2	1	1	1	1	1
Aliphatic Hydrocarbon Process Fluids, Chemicals	1	1	1	1	1	2	1	1
Aromatic Hydrocarbon Process Fluids, Chemicals	2	2	1	1	1	2	1	1
Aqueous Fluids: Water, Steam, Mineral Acids (H_2SO_4, HNO_3, HCl, etc.)	3	2	2	1	1	1	1	1
Amines, High pH Caustics (KOH, NaOH, etc.)	NR	NR	NR	3	3	3	3	1
Low Molecular Weight Carbonyls (MTBE, MEK, MIBK, etc.)	NR	NR	NR	NR	NR	NR	NR	1

1=Excellent—Best choice of Viton® type(s) for service in this class of fluid/chemical; minimal volume increase, change in physical properties.
2=Very Good—Good serviceability in this class of fluid/chemical; small amounts of volume increase and/or changes in physical properties.
3=Good—Suitable for use in this class of fluid/chemical; acceptable amounts of volume increase and/or changes in physical properties.
NR=Not Recommended—Excessive volume increase or change in physical properties.

Material	Operating Temperature Range °F(°C)
Nitrile (NBR)	250 (120)
(Flouroelastomer) FKM	400 (200)
(Perflouroelastomer) FFKM	500 (260)
(Ethylene Propylene Diene Monomer) EPDM	300 (150)



OD (Outside Diameter) and ID (Inside Diameter) Coating Selection

Coating selection can vary to match different project requirements. The general rule is that an MIJ can be coated in the same coating as the pipeline itself. The special focus that is important to an MIJ is that the ID must also be coated to ensure long term performance.

One caveat is the coating cannot contain conductive ingredients in the mix even if they are intended to dissipate during cure. Residual elements are often left behind.

OD Coating Performance Requirements:

- Recommended OD coatings for MIJs in buried applications – 100% solids epoxy coatings are ideal. The MIJ OD will experience the same conditions as the pipeline OD overall, so consider this when selecting an OD coating for your MIJ application. Manufacturers should standardize these coatings as a default but there are some surprises that will come up now and then.

- Recommended OD coatings for MIJs in above ground applications – add a topcoat of polyurethane or equal that can battle the UV degradation of the primary coating.

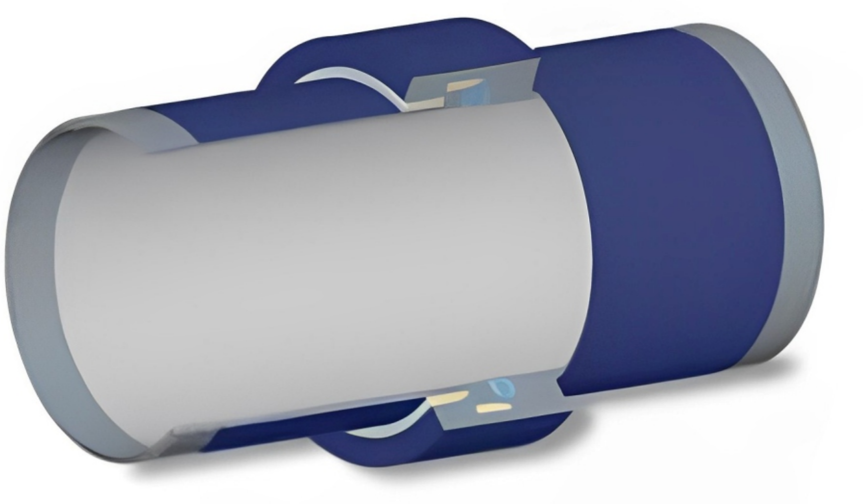
- Water absorption - lowest possible will deliver the longest life and ensures no electrolyte comes in contact with the steel surface. This will eliminate (or drastically reduce) the likelihood of corrosion occurring on the MIJ itself.

- Dielectric strength – The ultimate purpose of an MIJ is to block electrical current and contain it to the intended structure the CP system is protecting. The coating should not create a weak point in this system.

Risks associated with not coating the ID of the MIJ:

- Media directly contacting the isolating component can create a weakness in the MIJ over time, for example, through direct attack or slow erosion for example.

- Contaminants and debris can build up on the surface of the isolating component and act as a bridge for electrical current.



For Many (but not all) Designs There is an Epoxy Filler

Epoxy fillers must have high dielectric strength/resistance and must be viscous enough to fill all of the voids within an MIJ. If this is not done properly, air pockets can form where there is non-fill. The dielectric strength/resistance of air is high, but the problem is small amounts of moisture can be trapped depending on the humidity of the air when these bubbles are formed.

When it comes to this portion of an MIJ spec, it is best to ask questions about dielectric strength and the viscosity of the material proposed to ensure that it fills and cures in a way that will add long term integrity to the part and not create a weakness in a well-built MIJ.

Materials should meet or exceed the requirements of ASTM D709 (oil bath test of isolating materials)

Important note: ASTM D709 is a lab test for small coupon samples of isolating material. This is not currently a valid reference for the dielectric strength test for a completed MIJ. This is a gap in the market where there is not a clear direction on how to properly access the dielectric strength of a completed MIJ assembly. Therefore, dielectric strength tests on MIJs can be misleading and problematic.

That being said, it is still an important test to verify there are no weak points in the dielectric barriers within the joint that could break down from exposure to higher voltages of AC. The best method to mitigate problems with isolation joints due to exposure to high voltages of AC is to use a surge diverter, spark gap or solid state decoupler.

This will ensure the MIJ maintains its integrity throughout the life of the installation, even if high voltage interference occurs. Best practices for including these types of equipment are to bury the MIJ within a vault to ensure the decouplers or other equipment are installed to the respective manufacturer's requirements for buried applications.

Above ground is much simpler when installing these add-ons because they can be directly mounted with the standard cables used in flange connections.

Design Validation Testing

All production parts must be validated through destructive testing with a part(s) that can at a minimum validate the full range of sizes and classes offered. Individual destructive part testing at the order level is not necessary and is very expensive.

Hydro bend testing ensures the parts can handle the loads and moments that are often experienced during installation and during the service life of the part. The parts should be able to withstand this testing and still hold pressure and successfully isolate after experiencing the destructive test conditions. The ideal result of this testing would be that the pipes deform when the bending load is applied but the central hub of the MIJ remain intact.

Testing Requirements for MIJs

Batch testing has been confirmed to be invalid for MIJs. Each MJ produced is exposed to the same set of risk as the prior joint, but the variables reset every time you build a part. By testing 1 of 5 that were produced (with the same heat, the same lot of raw materials and the same welder etc.) does not validate the whole batch. 100% of parts must be tested to ensure they will perform as intended for their service life. The only time this can be waived is for pressure testing if the intention is to pressure test the line after the MIJ is installed. This can take the place of shop testing on 100% of the MIJs ordered for a given project if the end user is comfortable with this. We will add a word of caution though, project delays at this stage in the project can be extremely problematic, therefore, if you choose to wait for testing until it is installed, know the risks. For minimal risk, less critical applications, exceptions can be made if the cost of such testing outweighs the benefits.

Additional Testing Recommendations/Suggestions:

- Heat # match of steel goods (Pre inspection meetings).

- Dimensional inspection of components against approved drawings (Pre inspection meetings).

- Weld Inspection that is performed to the customer approved standard (API, ASME) using methodologies such as phased array ultrasonic testing, mag particle and visual inspection. Radiographic testing can be of value as well.

Electrical resistance and dielectric strength testing:

- The customary practice is to ensure the MIJ can achieve 5 MOhm resistance or greater when exposed to 1000 V DC. This is sufficient for any CP system that would typically be used where proper isolation is implemented. Some applications have unique requirements, but this is a safe baseline for most applications.

- Low pressure pneumatic testing offers a true test of a good seal within the hub of the MIJ. It is important to not test at higher pressures because this energizes the internal sealing elements and makes it easier to create a seal while the purpose of this test is to ensure that even in a static state the part is fully sealed.

- Hydrostatic and hydro fatigue testing offer assurance that the internal components have been properly assembled to create a pressure tight seal during production. If there is a degradation of electrical resistance post hydro test, it is possible that water has entered the body of the MIJ during pressure testing. It is important to note that electrical testing while the joint is still wet from hydro testing will yield lower resistance values, but the MIJ should still be able to resist enough voltage to perform as intended in service. See electrical testing above.

Coating inspection:

- The key to coating inspection is quite simple. Ensure there is a qualified NACE inspector performing the inspection and this will mitigate most, if not all, risk associated with coating.

Explanation of Common Reference Codes for Design and FAT Acceptance Criteria Used in MIJ

ASME VIII Div I Appx. 2

- Pressure vessel code.
    - Section 8 Mandatory appendix 2
        - Isolation joint body component design
        - Collar/Flange A/Flange B
        - Minimum part dimensions calculated based on part size/Pressure rating for given maximum stress levels based on a specific material and allowable operating temperature range.

ASME section 2

- Section 2 gives allowable stress for materials. This is a function of maximum and minimum allowable operating/design temperatures.

ASME 31.3/31.4/31.8

ASME B31.3

- Design of chemical and petroleum plants and refineries processing chemicals and hydrocarbons, water, and steam. This Code contains rules for piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals.

- This code will be used to design piping systems within a facility or specific (rig on/offshore). We would want to make sure that the pipe used to make the isolation joints meet code material requirements and pressure ratings for the pipe and joint fit within the calculated limits given in the code, based on design, safety, and location factors given by the customer.

ASME B31.4

- This Code prescribes requirements for the design, materials, construction, assembly, inspection, and testing of piping transporting liquids such as crude oil, condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, carbon dioxide, liquid alcohol, liquid anhydrous ammonia and liquid petroleum products between producers' lease facilities, tank farms, natural gas processing plants, refineries, stations, ammonia plants, terminals (marine, rail and truck) and other delivery and receiving points.

- Piping consists of pipe, flanges, bolting, gaskets, valves, relief devices, fittings and the pressure containing parts of other piping components. It also includes hangers and supports, and other equipment items necessary to prevent overstressing the pressure containing parts. It does not include support structures such as frames of buildings, buildings stanchions or foundations

- This code is applicable to transportation piping systems. Piping systems that are used to transport product from one point to another. This really is where our joints live, typically we are tied into a transport line. We will be concerned with meeting design requirements given for fitting and pressure containing parts. We also will use code calculations to make sure our materials of construction, specifically steel components, meet minimum required dimensional and mechanical requirements given by the customer. Really, we are just checking to make sure that what the customer is asking for will fit the pressure, temperature, and size requirements they are giving us.

ASME B31.8

- This Code covers the design, fabrication, installation, inspection, and testing of pipeline facilities used for the transportation of gas. This Code also covers the safety aspects of the operation and maintenance of those facilities

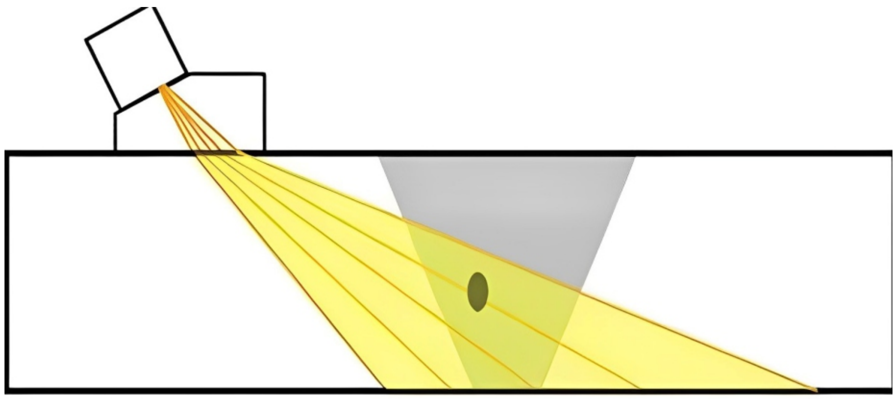
- See bullet point 3 for B31.4

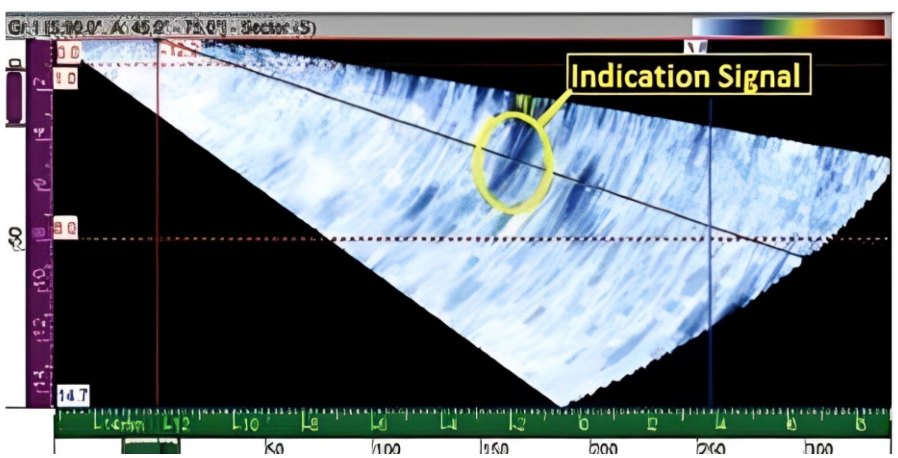
ANSI Pressure Test Tables

- ASME B16.5 and B16.47
  - Pressure and temperature rating for group 1 materials used to define pressure class of isolation joint. Isolation joint pressure classes will follow given pressure/temperature rating per pressure class in flange specification.

Welding reference codes and NDT reference codes

- API 1104
  - Mostly used for pipeline welding in the field. This code covers both the welding qualifications and procedural requirements. It also governs how to inspect a weld and what the acceptance criteria should be for an inspector to adhere to.
- ASME Section IX and ASME Section V
  - Section IX is specifically used to govern the welding qualifications and procedural requirements that determine how you weld a part and what materials can be welded together per the code. ASME section V offers guidance on NDT inspection methodology/procedural requirements and acceptance criteria for the inspector to grade the welds against. ASME is more commonly used as a shop/fabrication reference code as compared to API being used more in the field environment.





While most shops should be capable of welding to both standards in terms of compliance with the final inspection criteria, the ASME reference codes are more applicable to a shop fabrication environment and put more stringent controls in place. When welding in a shop environment, it is easier to control the variables and therefore welds should be completed to a higher standard when compared to welding in the field in an uncontrolled environment. Both codes are capable of producing quality welds, but the end user should defer to state and federal regulations and project requirements depending on the criticality of the application.

Conclusion

To conclude, this document is to be used as a reference when considering what to include in your business's Monolithic Isolation Joint specification. This is not a comprehensive prescription for all applications or uses of an MIJ. If you need any support or have a question regarding your specific application, we strongly recommend you contact GPT Industries or your MIJ manufacturer.

The global requirements for MIJs are dynamic and tend to be difficult to account for under one generic spec but we hope this helps give some guidance and clarity to those who are looking for answers when working to build out their internal requirements for sourcing MIJs.

GPT Industries

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