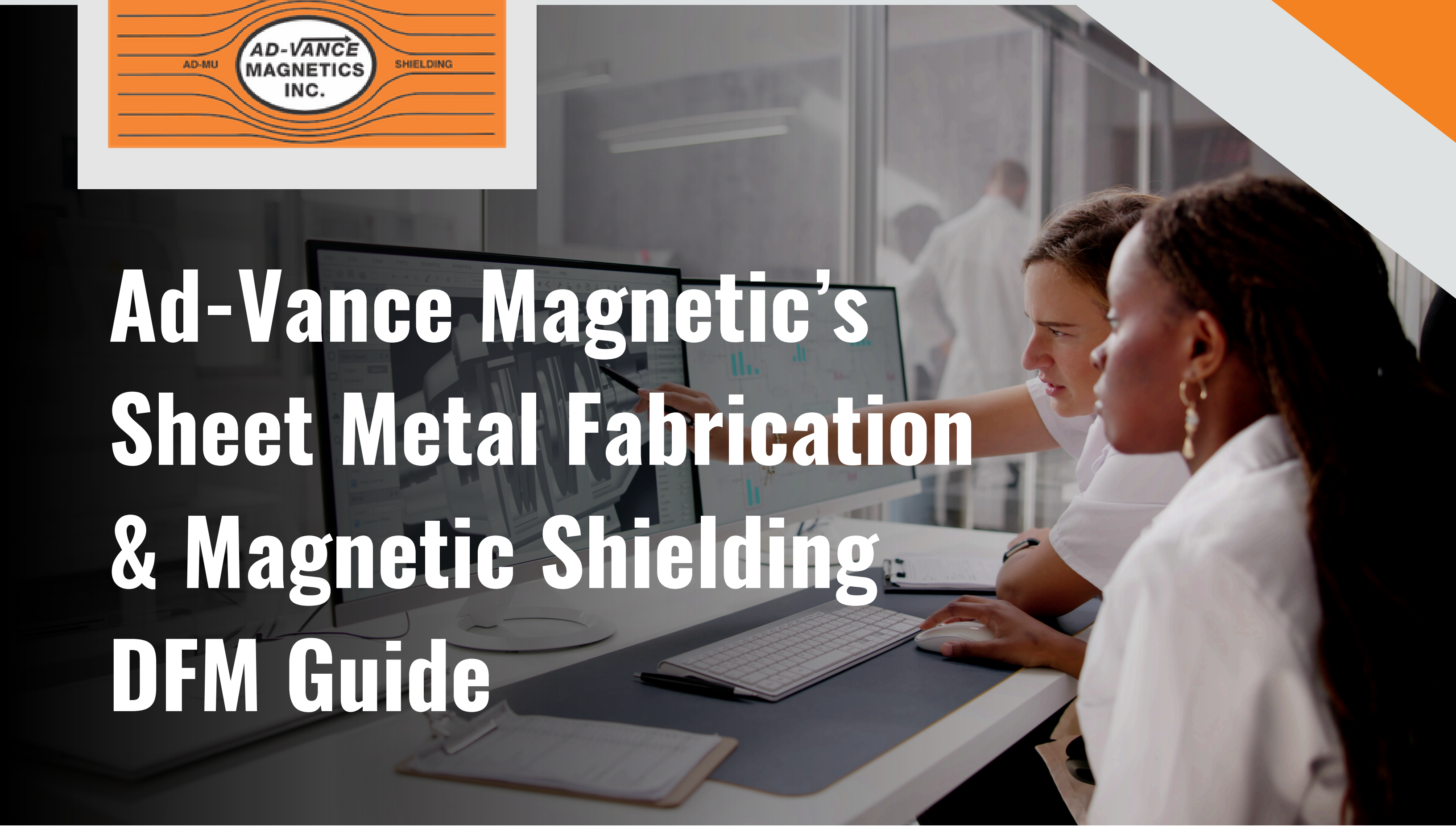


Ad-Vance Magnetic's Sheet Metal Fabrication & Magnetic Shielding DFM Guide

Design for manufacturability (DFM) is one of the most effective ways to reduce cost and avoid production delays while ensuring optimal magnetic shielding performance.

Ad-Vance Magnetics Inc. offers DFM insights to help ensure efficient and effective metal fabrication and shielding results. With expertise in both sheet metal fabrication and high-performance magnetic shielding, our team partners with customers during the design phase to reduce risk, optimize features and ultimately produce the best products possible.

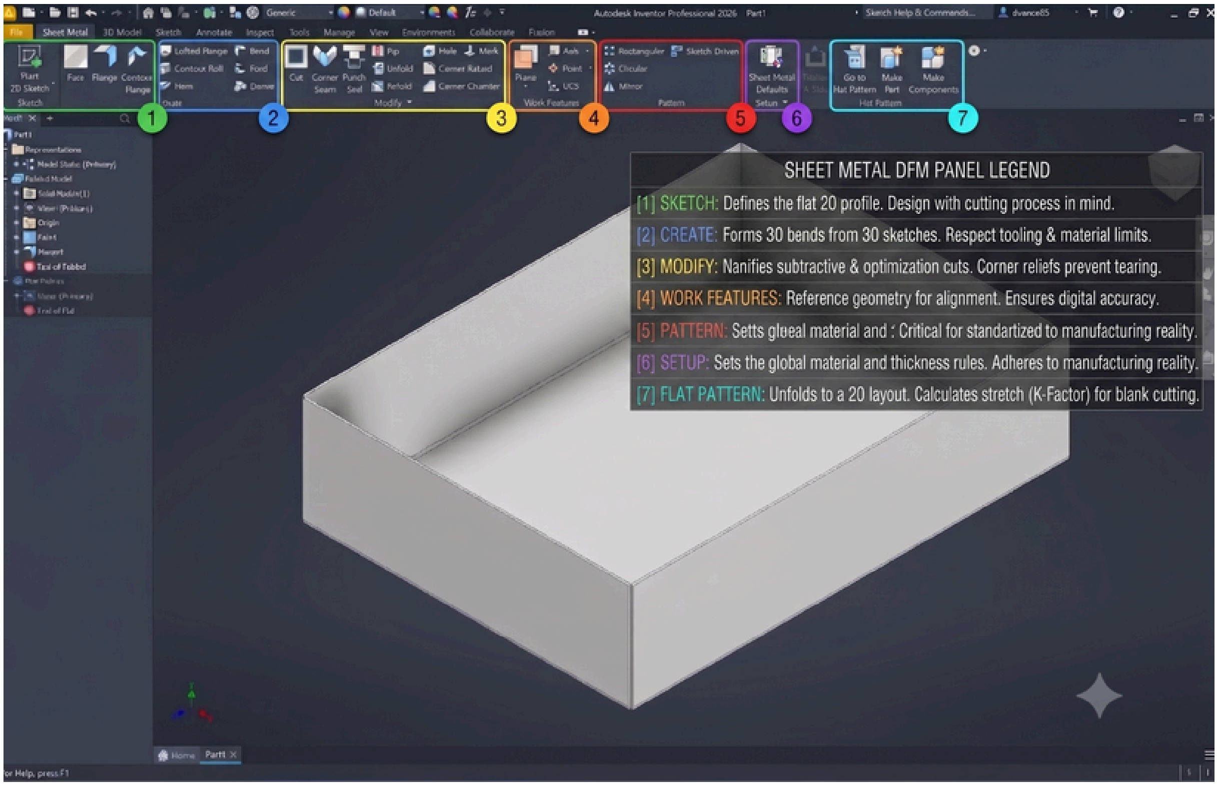
The following DFM guidelines are based on Ad-Vance Magnetics' real-world manufacturing experience and are intended to support informed design decisions and reliable outcomes.

AD-MU AD-VANCE MAGNETICS INC. SHIELDING

Phase 1: Project Engineering and Digital Design

Designing components with manufacturing in mind will help ensure success as the project progresses.

Use Sheet Metal Modeling not “Solid Modeling”



Designing sheet metal parts as solids introduces several manufacturing drawbacks, including inaccurate flat patterns, incorrect bend allowances, increased programming time, and unnecessary production costs. Furthermore, solid modeling fails to account for sheet-metal-specific tooling, often leading to unmanufacturable geometries that require costly design revisions.

Use a dedicated sheet metal tool in a CAD platform, including SolidWorks, Autodesk Inventor, or Creo. This will ensure:

- Accurate flat patterns
- Predictable bend behavior
- Faster programming
- Fewer production revisions

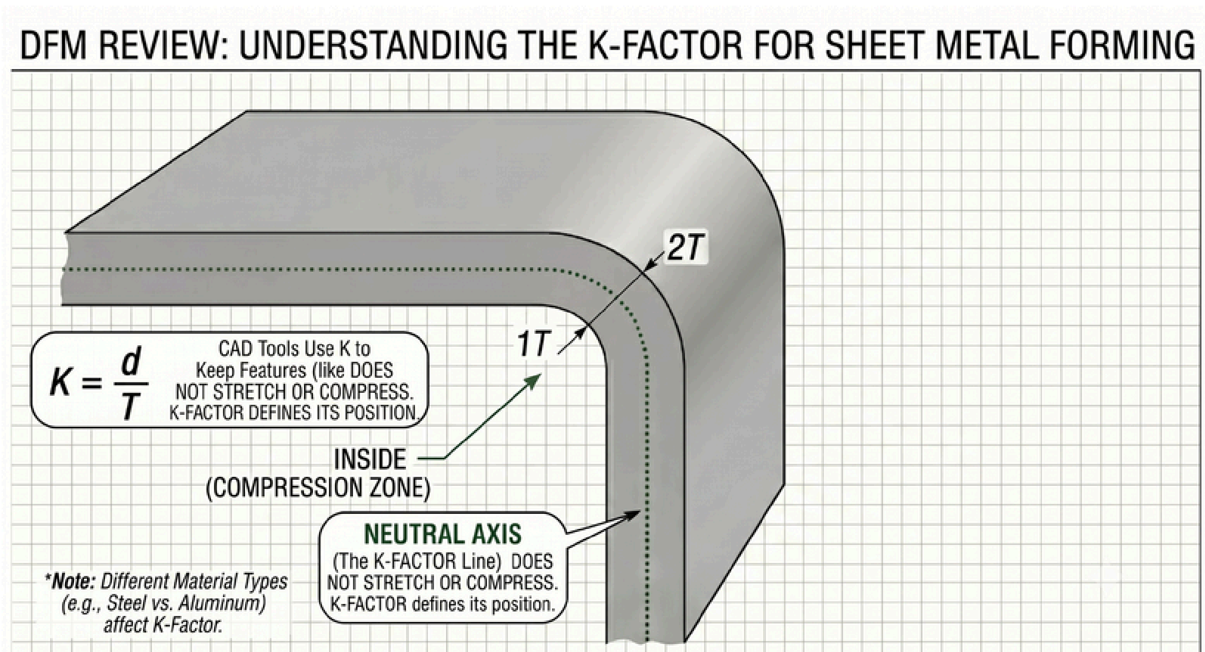
Why Using the Proper CAD Method Matters

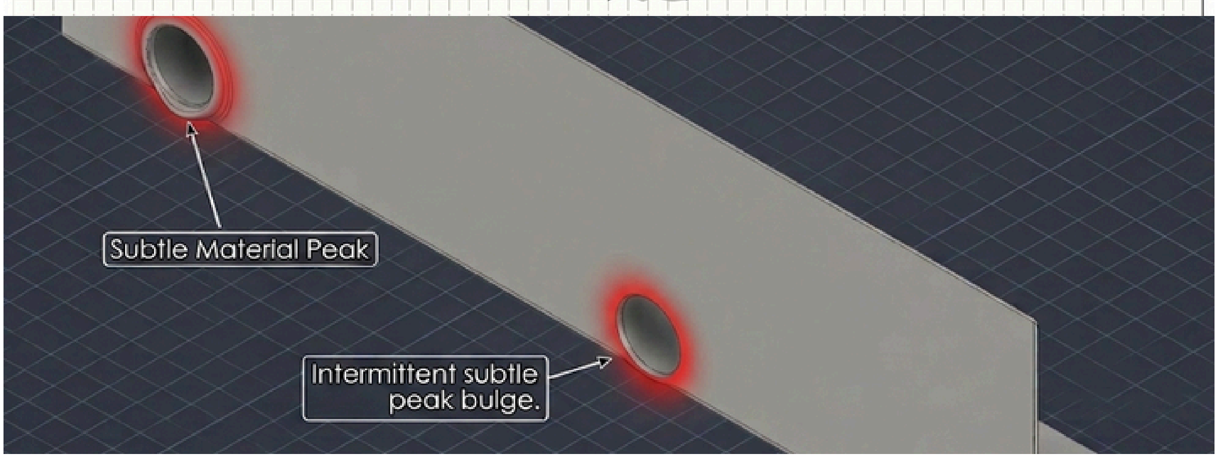
IT ACCOUNTS FOR MATERIAL BEHAVIOR

The K-Factor: When sheet metal is formed, it isn't simply folded. The material stretches on the outside of a bend and compresses on the inside. CAD sheet metal tools automatically calculate this based on the K Factor. This ensures features like holes and slots remain in the correct position after forming. Different materials and forming methods (air bending vs. coining) will also affect final geometry.

Critical CAD Rule: Match Inside Radius to actual Tooling

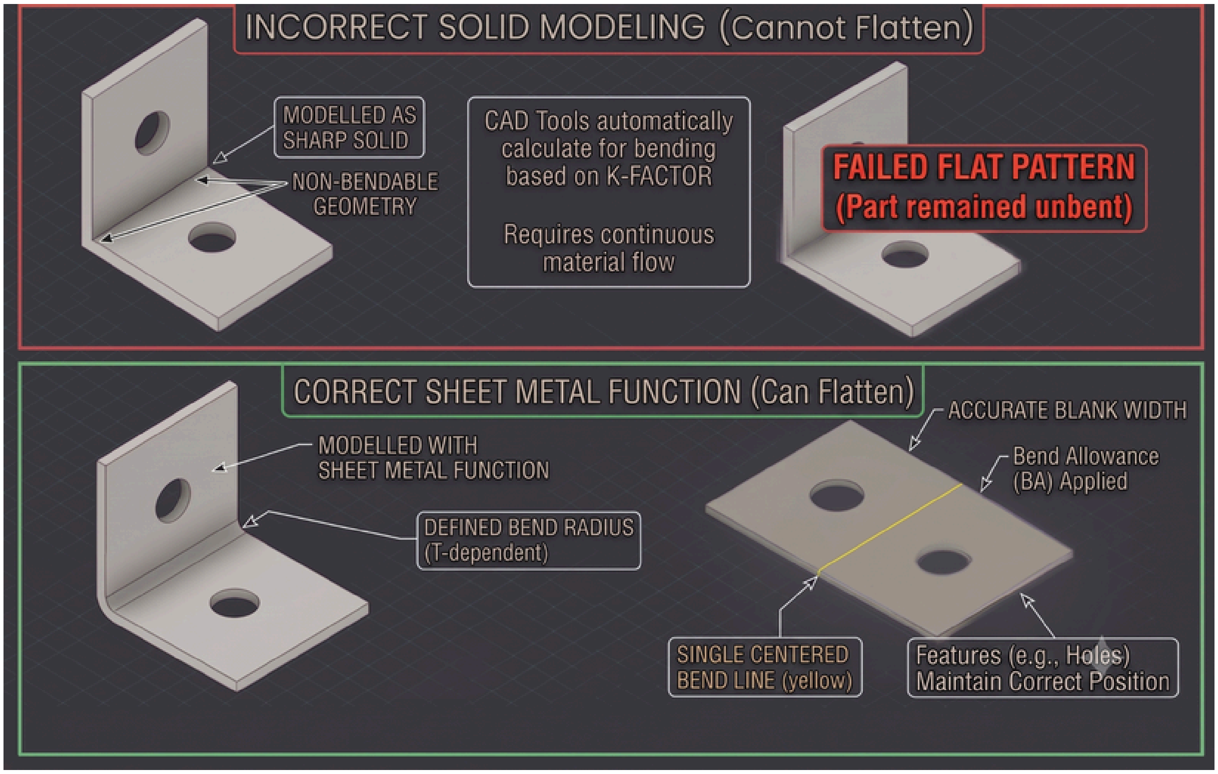
- Because the software relies on these geometric calculations, **do not model sharp inside corners** or leave tight CAD software defaults (like 0.010") unless coining is explicitly required. The internal radius in your 3D model must perfectly match the actual radius produced by the shop floor's air-bend tooling (recommended minimum of 1 times Material Thickness). If the 3D model utilizes sharp corners while production uses an air-bend radius, the final flat layout blank size will be wrong, and features like holes or slots near the bend lines will shift out of tolerance in physical reality.





It Supports Design for Real-World Forming

- Corner Reliefs: Extremely sharp corners in CAD are not physically manufacturable.



- **Flat Pattern Verification:** If a part cannot be flattened in CAD, it cannot be manufactured accurately in sheet metal.

- **Material Thickness:** Model using standard material thickness (e.g., .020", .040", .062"). Non-standard thicknesses increase cost and sourcing complexity.

Avoid Over-Tolerancing to Keep Costs in Check

Over-tolerancing is the primary driver of unnecessary costs and lead time in ALL sheet metal fabrication projects, including magnetic shielding.

- **Functional vs. Aesthetic Features**: Not all features require tight tolerances. For example, a tolerance of +/- 0.015" or greater is often sufficient for general brackets and non-mating covers. Many CAD title blocks default to a tighter tolerance of +/- 0.005, which may be unnecessary for many parts. Loosening tolerances even slightly can make them less expensive to produce..
- **Tolerance Stack Up**: In sheet metal fabrication, tolerances stack across every bend, creating a cumulative error that grows with the complexity of the part. Each individual bend introduces a small margin of deviation, and expecting high precision across five or more bends without utilizing specialized (and expensive) checking fixtures is a common design pitfall.
- **Magnetic Shielding Consideration**: High-temperature annealing causes material movement. Overly tight tolerances often require expensive custom fixturing or manual correction post-process to bring the part back into specification.

Ad-Vance Tip: *Use the widest tolerance your application allows. Only apply "tight" callouts to critical mating features, such as hole patterns for mounting, to keep costs and needs aligned.*

Phase 2: Laser Cutting and Feature Placement

Ad-Vance achieves repeatable, complex geometries by utilizing high-speed fiber and CO2 lasers. It is critical to design your sheet metal and magnetic shielding components for these thermal cutting processes.

Design with the Heat Affected Zone (HAZ) in Mind

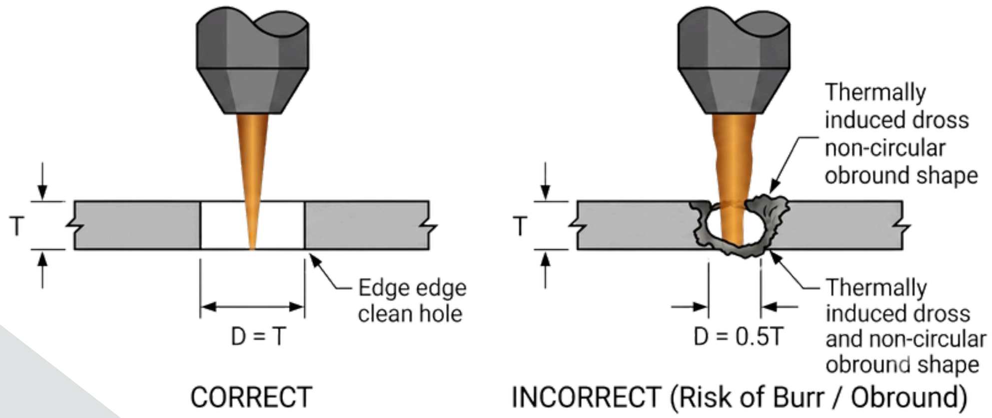
Laser cutting alters the grain structure at cut edges. The final annealing process restores magnetic performance by relieving this stress.

Optimize Feature Geometry

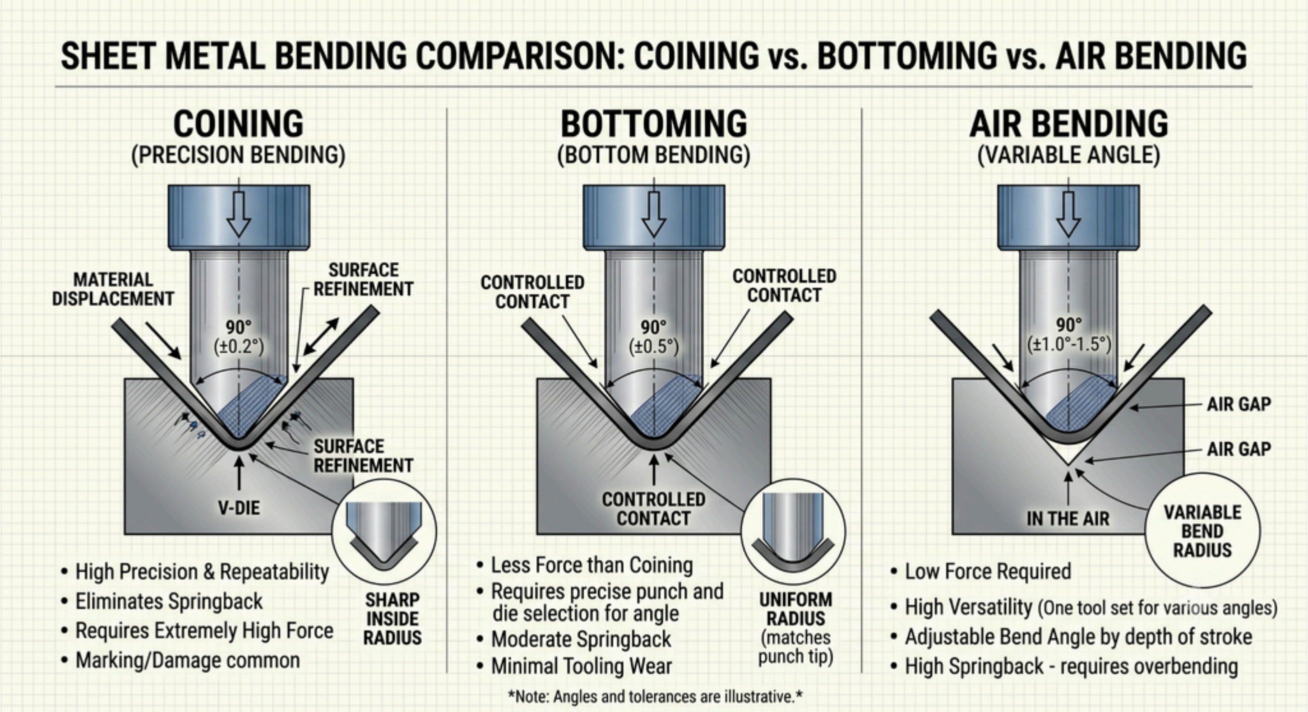
- **Minimum Hole Size:** The hole diameter must be at least 1 x material thickness to ensure clean edges.
- **Hole-to-Bend Distance**: Hole edges must be at least 2 x material thickness + bend radius away from any bend line.

Proper spacing prevents distortion during forming.

Minimum Hole Size



Phase 3: Bending Methods: Air Bending vs. Coining vs Bottom Bending



Magnetic shielding performance depends on how the material is formed. Depending on design requirements, Ad-Vance utilizes one of three forming methods: coining, bottoming, or air bending.

Air Bending vs. Coining vs. Bottom Bending

- Air Bending (Preferred)
  - Lower forming pressure
  - Less material stress
  - Recommended internal bend radius of at least 1 x times material thickness

- **Coining (When Required)**
  - Higher precision
  - Produces sharp corners
  - Requires high tonnage
  - Introduces greater material stress

- **Bottom Bending (When Required)**
  - Moderate precision
  - Reduced springback
  - Moderate tonnage
  - Less tool wear compared to coining

Tooling Interference: Watch for “Narrow Returns” and “Deep Channels”

- When reviewing your 3D geometry, consider the physical shape of the press brake tooling. Avoid designing deep, narrow U-channels, top-hat profiles, or tight return flanges where a standard goose-neck punch or die will physically collide with an already-formed flange. Maintain wide channel geometries or consult with our engineering team to ensure your part can be formed without requiring expensive custom hit sequences or destroying completed bends.

Bending Relative to Material Grain Direction:

- **High-Permeability Shielding Alloys (e.g., Ad-Mu-80):** In its raw fabrication state, this material forms and bends similarly to 300-series stainless steel. After the last forming operation is complete, parts must be fully annealed to achieve maximum shielding characteristics. Any mechanical work performed after this final anneal will permanently degrade performance.

- **Mild Steel & Stainless Steel:** For standard fabrication steels and stainless steels, grain direction has negligible impact and does not matter for standard engineering bends.
- **Aluminum (Material & Orientation Matters)**: 5052-H32 Aluminum is the industry-standard default for sheet metal forming. Its unique 1/4-hard temper provides the ideal balance of structural strength and excellent formability. When designing aluminum components, ensure critical structural bends are oriented against (perpendicular to) the material grain. Bending aluminum perfectly parallel to the grain results in severe "orange-peeling" and a high risk of catastrophic cracking along the outside radius.

📊 Aluminum Minimum Inside Bend Radius Chart

To prevent cracking or structural failure when air bending aluminum, use the following guide to establish your minimum internal bend radius relative to material thickness (T):

Aluminum Grade & Temper	Min Radius at 0.020" (T)	Min Radius at 0.040" (T)	Min Radius at 0.062" (T)	Bending Characteristics
1100-O	0.5 x T (Sharp)	0.5 x T (Sharp)	0.5 x T (Sharp)	Dead soft; can bend flat on itself cleanly.
3003-H14	0.5 x T	0.5 x T	1.0 x T	Highly ductile; excellent for intricate

5052-H32 (Recommended)	1.0 x T	1.0 x T	1.5 x T	Industry standard; reliable forming.
6061-O (Annealed)	1.0 x T	1.0 x T	1.5 x T	Bends easily, soft; must be heat-treated post-forming.
6061-T4	1.5 x T	2.0 x T	2.5 x T	Moderate formability; holds higher structural strength.
6061-T6	2.5 x T	3.5 x T	4.5 x T	Highly brittle; cracks easily. Requires very

Ad-Vance Tip: *Larger bend radii improve magnetic flux flow, significantly increasing shielding effectiveness. Conversely, sharp corners create "flux crowding," which can lead to localized saturation and reduced performance. We recommend air bending to avoid the flux crowding typical of sharp corners, unless specific project requirements suggest that coining is the necessary method.*

Phase 4: Welding and Assembly Integration

Welding is critical to structural integrity, but requires careful feature placement to manage localized heat.

Precision TIG Welding (Heli-arc)

- **Clearance:** To prevent thermal distortion, maintain a minimum distance of .125” or 3T (whichever is greater) between a weld bead and any hole or edge.
- **Specify Weld Requirements:** All welds are delivered “As Welded” unless the blueprint states “Grind Weld Flush”.
- **Grinding:** All grinding must be performed before annealing to reduce stress

Spot Welding (RSW)

- **Recommended Pitch:** A pitch of .75” to 1.5" will prevent electrical shunting and ensure magnetic continuity.
- **Maintain Proper Seam Overlap:** For multi-part assemblies, like boxes and cylinders, a seam overlap of .250” or 5T (whichever is greater) will minimize magnetic leakage.
- **Show Side:** Identify the "show side" on drawings to minimize indentation marks on cosmetic surfaces.

Material Thickness (T)	Minimum Pitch (Structural)	Recommended Pitch (Shielding)
0.020"	0.400"	0.75" – 1.00"

0.040"	0.800"	1.00" – 1.25"
0.062"	1.200"	1.25" – 1.50"

Phase 5: Fitment and Final Assembly

Designing with proper clearances is the key to a seamless final assembly.

Press-Fit Hardware Guidelines: When utilizing self-clinching fasteners (such as PEM® nuts, studs, or standoffs), the host sheet metal must physically displace and cold-flow into the fastener's undercut or locking knurl during installation. To ensure proper material flow and structural retention, designs must adhere to two strict geometric rules:

- **Hole Clearance and Dimensional Accuracy:** Laser-cut mounting holes for self-clinching fasteners should be held to a realistic bilateral tolerance of **+/- 0.003"**. Avoid modifying hole sizes to be looser or tighter than specified engineering baselines. An oversized hole deprives the fastener of the material it needs to displace, leading to low torque-out values, while an undersized hole prevents the shank from properly centering.
- **The "Meat" Rule (Minimum Edge Distance):** To prevent the outer edge of your component from bulging, buckling, or sweeping outward during press operations, you must maintain sufficient material volume around the hardware. As a reliable manufacturing baseline, **the distance from the edge**

of the mounting hole to the outer edge of the sheet metal must be at least 3 x Material Thickness (T).

This 3 x T baseline provides a necessary safety buffer for standard and wide-body floating hardware alike, ensuring the sheet metal can absorb installation forces and flow cleanly into the fastener's retention features without deforming the part profile.

⚠️ **Failure Mode Warning: Bulging, Push-outs, and Spin-outs**

Violating the minimum edge distance does not just cause a cosmetic issue; it triggers critical structural hardware failure. When the host sheet metal lacks sufficient edge volume ("meat"), the installation force causes the metal to bulge outward away from the fastener instead of flowing inward. This prevents the material from filling the hardware's locking teeth and undercut groove. Consequently, the fastener will fail to achieve its rated retention values, resulting in immediate **torque-out (spinning)** or **push-out (dislodging)** during final assembly.

Use the Right Hardware

All fasteners, including screws, bolts, nuts, and washers, that are used to assemble or mount to magnetic shields must be non-ferromagnetic.

- Approved materials include:
  - Brass
  - 300-series stainless steel
  - Nylon

Ad-Vance Tip: *Install brass and nylon hardware after annealing to prevent contamination or damage.*

Design for Assembly Fit

- **Slip Fit Clearance**: A clearance of 0.005" to 0.020"+ is recommended for mating parts.
- **Coatings:** Add 0.003" to 0.005" per surface when painting or powder coating is required.

Application Type	Recommended Total Clearance
Precision Fit	.005” - .008”
Slip Fit (Recommended)	0.010" - 0.015"
Loose Fit (Best when components need to come apart and go together)	0.020" +

Phase 6: The Magnetic Shielding Process

Raw material is provided in a “mill annealed” state, to allow for fabrication. Fabrication processes such as laser cutting, forming, and welding introduce stress that reduces permeability. The annealing process “heals” these stresses, allowing the finished product to reach its peak magnetic shielding performance by:

- **Restoring grain structure**
- **Relieving internal stress**
- **Enabling peak magnetic performance**

Avoid Post-Anneal Handling

After annealing, the material is highly sensitive to mechanical stress. Processing such as drilling and bending after final annealing permanently reduces shielding effectiveness. While risky, Ad-Vance does have the expertise to add hardware post-annealing if necessary. Reach out to our team to learn more.

Driving Your Design to Peak Performance of Magnetic Shield & Sheet Metal Components

Final Engineering Checklist

Before releasing a design, ensure you meet the following requirements:

[ ] **CAD Methodology:** Is the part designed in a dedicated sheet metal environment using the correct material K-Factor to prevent feature drift?

[ ] **Hole-to-Bend Distance:** Are all hole and slot edges located at least 2x Material Thickness (T) + Bend Radius away from any bend lines to prevent mechanical distortion during forming.

[ ] **Hole-to-Weld Clearance**: Are all hole and slot edges located at least .125" or 3T (whichever is greater) away from TIG weld beads to prevent thermal distortion within the Heat Affected Zone (HAZ)."

[ ] **Press-Fit (PEM®) Holes & Clearances**: Are laser-cut hardware mounting holes toleranced to +/- 0.003", and is the distance from the edge of the hole to the edge of the part at least 3 x Material Thickness (T) to ensure proper metal cold-flow into the locking teeth?

[ ] **Magnetic Bridges**: Are all mating seams designed with an overlap of .250'' or 5T (whichever is greater) to ensure low-reluctance flux continuity?

[ ] **Precision Fitment**: Is a minimum of .010'' clearance provided for slip fits, accounting for an additional .005'' per surface? Are considerations made if powder coating or painting is required?

[ ] **Stress Management**: Are all grinding and deburring callouts clearly labeled on the blueprint to ensure they are completed before the final annealing stage?

[ ] **Post-Anneal Protocol**: Is the final anneal clearly identified on the print as the last step, with a "No Mechanical Work" warning for downstream assembly?

[ ] **Hardware Check**: Is non-ferromagnetic hardware specified to prevent magnetic short-circuits?

Contact Us Today for DFM Guidance

www.advancemag.com/contact-us/ (574)-223-3158

Designing for Success Starts Early

Effective magnetic shielding starts in the design stage. To reduce costs and improve lead times while ensuring optimal shielding performance, address manufacturability early.

At Ad-Vance Magnetics Inc., we offer guidance to identify risks early and deliver design solutions that support a seamless transition from CAD to production, ensuring performance as expected in real-world environments.

For more DFM tips, contact Ad-Vance Magnetics today, or request a quote to get started on your next project.

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