BUYER EDUCATION SERIES · TECHNICAL GUIDE TG-003 · FIRST EDITION

Tagging Metal Assets with UHF RFID

Why the most common material in industry is also the hardest to tag, how on-metal constructions turn that obstacle into an advantage, and how to specify, print and validate an asset-tagging programme that survives contact with a real plant.

Written for the person who has to explain, a year from now, why every tag still reads.

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APPLIES TO	Passive UHF RFID (860–960 MHz) labelling of metal and other conductive surfaces, including print-and-encode of flexible on-metal labels.
INTENDED AUDIENCE	Asset management, maintenance and IT procurement; systems integrators; technical sales.
COMPANION DOCUMENT	JNX-TG-002, *UHF RFID Printer-Encoders — A Buyer's Technical Guide*, which covers the tag × chip × encoder system in full.
PREPARED BY	JNXRFID product marketing — compiled from the published engineering literature (see References).
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FRONT MATTER

About this guide

Why metal deserves its own guide

Ask an integrator which surface causes the most RFID project failures and the answer is nearly always the same: metal. It is not a niche problem. Racks, shelves, tools, machine frames, IT hardware, pipes, vehicles and returnable containers are conductive, and a labelling method that works on cardboard cannot be transplanted onto them. The failure is also unusually deceptive: a tag that reads perfectly across a desk can fall silent the moment it touches a cabinet door, which invites the conclusion that the hardware is defective. It almost never is.

This guide explains the mechanism in enough depth to reason about it, describes the constructions that solve it, and sets out how such labels are printed, encoded, installed and validated. It is deliberately narrower than its companion volume: one surface, examined properly.

Purpose and scope

In scope: the physics of conductive surfaces; on-metal construction types and how to choose between them; chip selection as it applies to thick constructions; printing and encoding flexible on-metal labels; installation practice; validation protocol; and troubleshooting.

Out of scope: non-metal surfaces; high-frequency (13.56 MHz) tagging; active and battery-assisted tags; portal and reader network design; and specific product quotations.

> **A NOTE ON WHAT THIS GUIDE IS NOT**
> JNXRFID builds RFID printer-encoders and desktop readers. It does not manufacture tags or label media. The constructions described here are bought from tag manufacturers and label converters; the role of this guide is to make you an informed buyer of them, and to explain what your encoding equipment must be able to do with what you buy.

Who this is for, and how to read it

- **Assessing feasibility (≈15 minutes).** Read §1 and §2. Together they explain why the obvious approach fails and what the working approaches cost.
- **Specifying a programme (≈45 minutes).** Add §3, §4 and §5, which cover selection, printing and encoding, and validation.
- **Fixing a live problem.** Go to §6, the failure-mode table, then trace back to the section it cites.

Conventions

- Power is given in dBm and attenuation in dB; a 3 dB change is a doubling or halving of power. Chip sensitivity is a negative dBm where a more negative number is better.
- "On-metal" and "anti-metal" describe the same class of construction; this guide uses "on-metal" throughout.
- Thickness figures for flexible on-metal labels describe the common commercial class of roughly 1.3–1.5 mm. Individual products vary; the manufacturer's datasheet governs.

- Chip vendors are named because a chip is a component specified by part number. Tag manufacturers are not named, because the argument does not depend on any one catalogue.
- **Certification scope.** Where a third-party inlay programme is mentioned, the guide states what it certifies. A certificate covering an inlay model or an inlay manufacturer does not extend to the converted label you buy, and specialty constructions often sit outside such programmes altogether.

Revision history

EDITION	DATE	CHANGE
V1.1	2026-09-11	Added §2.5 on the cost structure and batch consistency of specialty constructions, with the requirements to write into a media specification. Extended §5 with the scope of third-party inlay certification programmes and what replaces it on an on-metal programme. Added a seventh failure pattern covering batch variance between deliveries. Extended §7 with the industries where conductive assets dominate the plant. Added a reference for inlay manufacturing and converting process documentation.
V1.0	2026-09-11	Initial release. Derived from §2.5 and the on-metal material of JNX-TG-002, expanded into a standalone guide.

FRONT MATTER

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FRONT MATTER

Terminology

Terms are defined here as they are used in this guide.

Conductive surface

Any surface that carries electric current when exposed to a changing electromagnetic field. Steel, aluminium, copper and carbon-fibre composites all qualify; painted or coated metal still qualifies, because paint is a thin dielectric, not a shield.

Detuning

A shift of the tag antenna's resonant frequency away from the operating band, caused by the electrical environment. A detuned tag may still power up but replies weakly, or not at all.

Ferrite layer

A magnetic material placed between antenna and metal. It behaves, to the antenna, like electrical separation, allowing thinner constructions than a foam spacer of equal performance.

Ground-plane effect

The improvement in antenna behaviour that a conductive plane produces when placed a controlled quarter-wavelength-like distance behind it. It is the reason a well-designed on-metal tag can read farther on metal than in free air.

On-metal tag

A construction engineered to operate with a conductive surface directly behind it, using a spacer or ferrite layer. A matched component, not a universal upgrade.

Program position

The position, relative to the print line, at which the inlay must sit for the encoder's write to succeed. Published per inlay for a given printer and region.

Spacer

A low-loss dielectric layer — commonly a closed-cell foam — holding the antenna away from the metal surface.

PART ONE · THE PROBLEM

1. Why metal defeats an ordinary label

A UHF tag is a tuned antenna. Bring a large conductor within a fraction of a wavelength of it and the antenna is no longer the thing you designed — it is the antenna plus the metal, behaving like something quite different.

1.1 The mirror in the circuit

An antenna near a conductive plane behaves as though a mirror image of itself existed on the far side of that plane. The currents induced in the metal surface radiate exactly as an identical antenna would, with a phase relationship set by the separation distance. When the tag sits directly on the metal, the image sits a hair's breadth away and is close to inverted — so the tag's own radiation and its mirror image cancel. The antenna's radiation resistance collapses toward zero, which is the electrical equivalent of trying to shout with a hand clamped over your mouth.

This is not a marginal loss. A conventional inlay in contact with a conductive surface routinely loses most of its free-air performance, and often falls silent entirely. Reported degradations for tags mounted directly on steel run from roughly 70 to 90 per cent of range, and a tag that reads several metres in air may manage centimetres — or nothing — on the asset it was bought for.

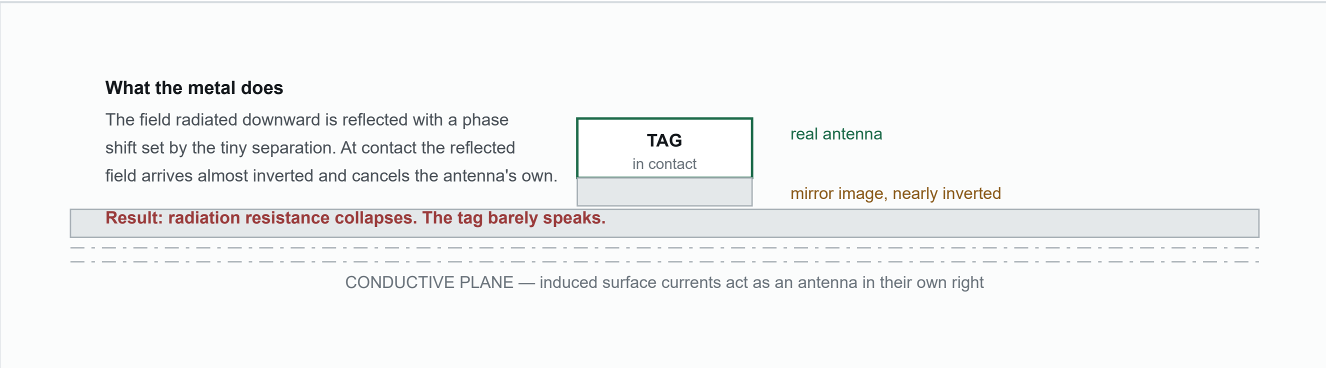

FIGURE 1 A tag against a conductive plane. See §1.1.

1.2 Eddy currents and detuning

Two further mechanisms compound the first. A changing magnetic field induces circulating currents in any conductor — *eddy currents* — and those currents generate a field opposing the original one, absorbing energy that the tag needed in order to power up. And the metal loads the tag's antenna electrically: its capacitance and inductance change, the resonant frequency slides out of the 860–960 MHz band, and the tag detunes. A detuned tag may harvest enough energy to wake and still be unable to reply usefully, which makes the symptom intermittent and hard to reproduce.

The same physics explains a related trap. Placing a standard label *behind* a metal object — between the metal and the reader — is no better, because the metal blocks the path entirely. And placing a label on the top layer of a metal-framed pallet, where the frame sits millimetres beneath the label, fails for the reason in §1.1 even though the label is not literally touching metal.

1.3 Why the failure is deceptive

Every stage of a typical project conspires to hide the problem until it is expensive. Tag samples arrive and are tested across a desk in free air, where they perform beautifully. Acceptance is signed on that evidence. The first full-scale installation puts the labels onto the actual assets and the read rate collapses — and because the same labels read perfectly a metre away from the asset, the fault looks exactly like a defective batch, or a weak reader, or bad configuration. Weeks of replacement and re-testing follow before someone tests a tag against a steel plate.

The corrective is procedural rather than technical, and it is short: **no on-metal programme is validated in free air.** Every read test from the first sample onwards happens on a production-representative surface, in the final orientation, at the final read distance. §5 turns that principle into a checklist.

PART TWO · THE SOLUTION

2. How on-metal constructions solve it

There is no way to make a standard inlay happy on metal. There are, however, well-understood ways to build a tag that expects the metal to be there.

2.1 Separation: the spacer

The oldest and most common remedy is physical distance. A low-loss dielectric layer — usually closed-cell foam — holds the antenna away from the surface. Beyond a few millimetres of separation the mirror image stops cancelling and starts behaving like the reflector behind a patch antenna: the metal that was destroying the antenna now improves it. As a field expedient, even a standard inlay raised three to six millimetres off a metal surface recovers usable performance; the difficulty is keeping such an arrangement alive through handling, vibration and cleaning, which is why purpose-built constructions exist.

2.2 The ferrite alternative

Where thickness is unacceptable, a layer of ferrite material — a magnetic ceramic with high permeability — can take the spacer's place. To the antenna the ferrite behaves like additional electrical distance, suppressing the image-current cancellation while adding far less physical thickness than foam. The trade-offs are cost and weight, and ferrite constructions are typically specified where the asset's geometry cannot tolerate a thicker label.

2.3 When metal becomes an advantage

Here is the counter-intuitive fact worth remembering, because it inverts the usual assumption: a well-designed on-metal tag frequently reads *farther* on a metal surface than the same tag reads in free air. The conductive plane, now at the designed distance, acts as a ground plane that increases the antenna's effective gain in the direction of the reader. The metal has been promoted from enemy to part of the antenna.

The corollary matters just as much. An on-metal construction is tuned around a conductive backing; put it on plastic or cardboard and that backing is missing, so it frequently performs *worse* than an ordinary inlay on the same surface. On-metal tags are a matched component, and matching is a two-sided obligation.

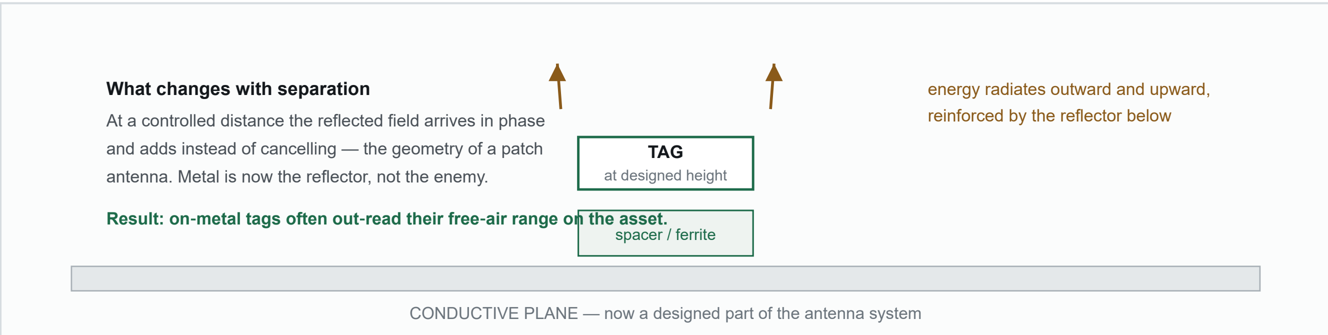

FIGURE 2 The ground-plane effect. See §2.1 and §2.3.

2.4 Construction classes compared

Commercially, the choice comes down to four classes. They differ in thickness, in how they are attached, in the range they deliver, and — the point most often overlooked at specification time — in whether they can pass through a printer-encoder at all.

TABLE 1 On-metal construction classes

CLASS	CONSTRUCTION	TYPICAL THICKNESS	ATTACHMENT	CHARACTER
Flexible on-metal label	Printable facestock over an inlay over a foam spacer, with adhesive liner.	~1.3–1.5 mm	Adhesive	The only class that runs through a printer-encoder, and only on machines rated for the thickness. Conforms to slightly curved surfaces. The default for on-demand programmes.
Ferrite-backed label	Ferrite layer in place of the foam spacer.	thinner than foam class	Adhesive	Where thickness is constrained. Costlier per label; check temperature rating for the environment.
Rigid on-metal tag	Engineered housing — PCB, ABS or PC — with internal spacer geometry.	several mm	Screws, rivets, cable ties, adhesive	Highest durability and typically the longest range. Cannot pass through a printer; commissioned with a desktop or handheld encoder.
High-temperature tag	Rigid housing in ceramic, PPS or stainless; specialty adhesives.	varies	Screws or welding	For paint lines, sterilisation and engine bays. Range and cost both rise with temperature rating.

> **THE COMPATIBILITY HEADLINE**
>
> Ordinary label stock runs from about 0.06 mm to 0.25 mm. Flexible on-metal labels sit roughly six times thicker, at about 1.3–1.5 mm, and only printer-encoders rated for that media class accept them — the encoder antenna sits a fixed distance from the media path, and the media has to fit through it. Rigid tags do not pass through any printer; they are commissioned separately. This single mechanical fact should be settled before media is ordered, not after.

2.5 Why on-metal media costs more, and why batches differ

On-metal constructions are specialty media, and the price and the variability come from the same source: they are assembled, not printed. A commodity smart label is essentially an inlay laminated under one layer of facestock. A flexible on-metal label is a stack — facestock, an inlay, a spacer or ferrite layer, adhesive, liner — and every additional layer is another lamination pass, another alignment to hold, and another route by which a finished roll can depart from the design.

Three consequences follow, and all three are visible at the buyer's desk rather than on the datasheet.

- **Cost is dominated by materials and assembly, not by the chip.** In commodity retail labels the silicon is the largest single cost element. In an on-metal construction, the spacer, the ferrite where used, the specialty facestock and the extra converting passes carry a much larger share — and the volumes are orders of magnitude smaller than retail, so none of it enjoys commodity economics. Expect a multiple of a standard label, not a percentage more.

- **The RF-critical work happens at the converter.** The chip is bought from a silicon vendor and the antenna is part of the inlay, but spacer thickness, layer alignment and the placement geometry are all set during converting. That is why a change of conversion is a change of product, even at an identical inlay part number — the mechanism described in JNX-TG-002, §2.7.
- **Consistency, not peak performance, is the thing to buy.** With more layers and lower volumes, unit-to-unit and batch-to-batch spread widens. A supplier whose best sample reads far and whose worst sample reads nowhere is harder to run a programme on than one whose samples all read alike.

What to write into the media specification

- **A placement guideline with tolerances.** The inlay centre, position and pitch that the printer's calibration depends on — the same three dimensions as any other converted RFID media.
- **A construction datasheet with the layer stack.** Spacer or ferrite type and thickness, facestock, adhesive and service temperature, so that a substitute material becomes visible rather than silent.
- **A batch record per delivery.** Inlay lot, converter and conversion date. Without it, a variance cannot be traced to anything.
- **An encode-and-verify sample per batch.** Ten labels taken from the middle of the roll and read individually — this finds the weak tail that a visual inspection and a first-label test both miss.
- **Thickness measured on receipt.** A spacer compressed in storage or lamination is thinner than specified and will detune, without looking defective.

PART THREE · SPECIFICATION

3. Choosing a construction

Selection is a short sequence of eliminations. Surface and geometry first, since nothing downstream can compensate for a construction the asset cannot carry; environment and attachment next; chip and data last, which is where most specifications start and where most of them go wrong.

TABLE 2 Selection factors, in the order they should be applied

FACTOR	WHAT TO ESTABLISH	WHY IT IS IN THIS POSITION
1. Surface and curvature	Is the mounting surface flat, slightly curved, or a tight radius? Is it bare metal, painted, or plastic trim on a metal object?	Curvature flexes the antenna and shifts tuning; the label must sit on the conductive surface itself, not on a non-metal layer over it.
2. Space available	Is there room for 1.5 mm of label, or only for a ferrite-thin construction?	Thickness decides the class (§2.4), and the class decides whether printing in-house is possible at all.
3. Environment	Temperature extremes, wash-down, solvents, UV, abrasion, sterilisation.	Adhesive and housing survive or they do not; RF performance is irrelevant once the construction delaminates.
4. Attachment	Adhesive, screw, rivet or cable tie — and whether holes may be drilled.	Mechanical attachment outlasts adhesive on high-value assets and permits retagging policy to be simpler.
5. Read geometry	Handheld scanning at close range, fixed portal, or robotically served station; which face of the asset will face the reader.	Required range and polarisation follow from this, and the tag's orientation on the asset should be fixed at this point.
6. Chip and data	EPC only, or user memory for maintenance history; AES authentication if the tag has a security role.	Chip choice is bounded by the encoder's supported list, so it belongs near the end — after the mechanical questions are settled.
7. Volume and programme shape	Labels a day; who encodes; whether media is printed in-house or pre-encoded by a converter.	Decides the encoding route in Table 3, which in turn decides the equipment specification.

THE MISTAKE THAT COSTS A RE-BUY

Choosing the chip first. A specification that opens with "Impinj M730" or "UCODE 9" and works backwards is choosing the least constrained variable first and the most constrained one last. Chip support is bounded by what the encoder can write, and the encoder's capability is bounded by the thickness the asset forces you into.

4. Printing and encoding on-metal labels

Encoding is radio work, and on-metal media is the thickest media a printer-encoder is ever asked to handle. Three questions decide the route: what thickness the machine accepts, which chips its firmware supports, and how the visual layer gets onto the label.

TABLE 3 Encoding routes for on-metal constructions

ROUTE	HOW IT WORKS	BEST FOR	CONSTRAINTS
Printer-encoder, flexible on-metal labels	Print and encode in one pass on a machine rated for media up to roughly 1.5 mm, with write-then-verify and automatic marking of failures.	On-demand asset labelling; programmes where artwork carries maintenance or ownership data.	Media thickness rating, inlay-placement geometry and firmware chip list must all be confirmed before ordering media.
Desktop encoder for rigid tags	USB desktop reader plus vendor software; one tag at a time at a commissioning bench.	Rigid and high-temperature tags, which cannot pass through a printer.	Manual throughput; visual identification is by engraving, embossing or a separate laminated label.
Handheld commissioning in the field	Scan-then-write at the asset, using a handheld or sled.	Retagging, retrofits, assets that cannot be brought to a bench.	Throughput depends on the operator; battery and ergonomics dominate.
Pre-encoded media from a converter	Converting house encodes before shipment; you print the visual layer only.	Pilots, urgent SKUs, low volumes.	Serial management moves outside your control; locked or pre-written tags must come with access passwords.

What to verify before the first production roll

1. **Media thickness against the printer's rating.** Ordinary stock runs 0.06–0.25 mm; flexible on-metal labels run roughly 1.3–1.5 mm. Confirm the machine's maximum, not its paper specification.
2. **The inlay's placement geometry.** Converted media carries three published dimensions — inlay centre (a), inlay position (x) and inlay pitch (y) — with tolerances typically ±3 mm. Media converted to a published guideline needs no RFID calibration; media that deviates from one does.
3. **The chip list.** Confirm that the chip inside the on-metal construction is on the encoder's supported firmware list. Thick constructions are a niche, and the inlay inside them is not always the family a brochure implies.
4. **Print quality over the inlay.** Print density degrades in the immediate vicinity of the chip, because the die sits proud of the facestock. Design the artwork around the chip location rather than across it.
5. **Media storage.** Store label rolls in stable conditions and limit exposure to electrostatic discharge; both affect encode yield before the printer is ever involved.

5. Installation and validation

A correct construction installed carelessly reads like the wrong construction. Installation discipline is cheap; discovering installation errors after rollout is not.

Installation rules

- **Clean and dry the surface.** Adhesives fail on oil, powder coat release agents and dust long before they fail on age.
- **Respect the cure time.** Adhesive bond — and therefore RF coupling — changes over the first hours after application. Validate after the manufacturer's cure period, not immediately.
- **Fix the orientation.** Decide which face of the asset meets the reader and label that face consistently. Orientation is part of the design, not an operator preference.
- **Keep the label on the metal itself.** A label sitting on a plastic trim panel or a decal over metal has lost its ground plane.
- **Avoid edges, seams and moving parts.** Edges concentrate field distortion; seams flex; panels that vibrate work the adhesive loose.
- **Do not stack metal against the face.** A tag that reads perfectly alone can be detuned by the steel shelf it is pressed against in storage.

Validation protocol

1. **Baseline on the real asset.** Measure read range on a production-representative asset — not in air, not on a sample plate — after adhesive cure.
2. **Record orientation, not just distance.** Note the tag's attitude and the reader antenna's position for every measurement, so that results are reproducible.
3. **Establish the worst case, then add margin.** Programme requirements should be written against the weakest realistic position — tag at the back of a shelf, asset half-full, door closed — with margin on top.
4. **Sample across the fleet.** Assets of the same model vary; test several units, not one.
5. **Re-test after the environment intervenes.** A wash cycle, a paint bake, a winter outdoors: whatever the asset actually experiences, the tag should be re-read after experiencing it.
6. **Archive the numbers.** The validation record is the reference against which any future "the tags stopped working" claim is judged.

> **THERE IS USUALLY NO CERTIFICATE TO LEAN ON**
>
> The publicly known third-party programmes that certify UHF inlay performance were built for high-volume retail supply chains. They certify an inlay *model* against defined requirements and an inlay *manufacturer's* quality system — and both stop at the inlay. The converted label sits outside that scope, and the specialty constructions this guide is about mostly sit outside it altogether, because their volumes are far below what such a programme is designed to police. Two practical conclusions. First, a certificate on an inlay does not transfer to the roll in your store. Second, on an on-metal programme your validation record *is* the quality evidence — which is a reason to write it down properly, not a reason to skip it. A supplier who can produce a placement guideline, a layer-stack datasheet and a batch record is giving you something more useful than a logo.

6. Failure modes

Most on-metal problems belong to one of the seven patterns below. The right-hand column gives the first move; if it clears nothing, the middle column tells you what to question next.

TABLE 4 Failure modes and first response

SYMPTOM	MOST LIKELY CAUSE	FIRST MOVE
Reads in air, silent on the asset	A standard inlay was used instead of an on-metal construction — the most common single cause	Confirm the construction class; test an on-metal label on the same asset
Reads at commissioning, fails days later	Adhesive not cured, or applied over contamination; the spacer has relaxed or lifted	Inspect the bond; re-apply to a cleaned surface and re-validate after full cure
Intermittent reads on one asset model	The label sits over a seam, rib or cable tray, or the panel vibrates	Map the asset's construction; move the label to a flat continuous area
Short range on every asset	Spacer compressed during lamination or application; wrong class for the read geometry	Measure a sample's thickness against the datasheet; re-check the read-point geometry
Reads on one face of the asset, not the other	Orientation against a linearly polarised antenna, or the metal geometry shadowing that face	Re-test at a fixed orientation; consider circular polarisation or a second read point
Encoder rejects the media outright	Media thickness beyond the machine's rating, chip not on the firmware list, or inlay geometry outside the published tolerances	Check the three mechanical facts in §4 before touching any settings
First delivery reads well, the next one does not	Batch variance from the converter — layer alignment, spacer thickness or a substituted material	Compare batch records, measure thickness on receipt, and re-run the per-batch encode-and-verify sample (§2.5)

7. Where on-metal tagging pays off

On-metal labelling is the enabling technique for asset classes that barcode programmes never managed to cover economically. The recurring pattern is a durable asset, a meaningful replacement cost, and a maintenance or compliance process that depends on knowing exactly which object is which.

- **IT and data-centre assets** — servers, racks, laptops and network hardware, where the asset register must survive equipment moves and the surface is always metal.
- **Tools, gauges and MRO inventories** — calibrated instruments that must be identified individually through calibration cycles, often with the calibration history in the tag's user memory.
- **Racking, shelving and warehouse infrastructure** — the fixed metal structure of a facility, labelled once and read for a decade.
- **Returnable transport items** — cages, dollies, kegs and containers that circulate between sites and are lost in proportion to how loosely they are identified.

- **Pipes, valves and plant equipment** — identification that must survive weather, paint and insulation, often with high-temperature constructions.
- **Sterilisable medical instruments and trays** — where the tag must survive autoclave cycles and the read happens at the set level, not the item level.

Three industries deserve separate mention, because in each of them the metal is not an exception to be worked around but the dominant material of the plant — and they are where on-metal labelling is moving from pilot to standard practice.

- **Battery and electric-vehicle component manufacturing.** Cells, modules, trays, fixtures and tooling are metal by necessity, and the process demands traceability of each carrier through every station. A label that must survive the line and be read at speed has to be an on-metal construction; there is no non-metal surface to move it to.
- **Photovoltaic and lithium-cell production.** Carriers, cassettes and process fixtures circulate between stations and are re-used thousands of times. Identification has to outlast the asset's own maintenance cycle, which pushes the choice towards the more durable end of the flexible class or a rigid tag.
- **Power generation, transmission and distribution.** Utility assets are metal, often outdoors, frequently painted or insulated, and sometimes buried. This is the environment that produces the widest range of constructions in one programme — flexible labels indoors, rigid and high-temperature tags on plant equipment, and purpose-built housings where nothing standard survives.

> **A NOTE ON HOW THESE PROGRAMMES START**
>
> They rarely start as an enterprise rollout. The usual entry point is one line, one asset class or one compliance requirement — a fixture pool that keeps losing fixtures, an inspection regime that needs per-asset records — and the programme expands once the read result is trustworthy. That is an argument for proving the construction on the hardest asset you own first, because a pilot that works only on the easy surfaces proves nothing that survives contact with the plant.

> **THE ECONOMIC ARGUMENT, STATED PLAINLY**
>
> An on-metal label costs more than a paper label and less than a single wasted maintenance visit. Programmes that fail economically almost always fail because the tag was chosen to be cheap rather than to be readable — and a tag that cannot be read is not cheap at any price.

APPENDIX

Appendix A. Commissioning checklist

Work through this before releasing a purchase order for on-metal media or the equipment that encodes it. The cross-references point to the reasoning.

Construction selection

- ☐ Mounting surface identified as conductive, and the label will sit directly on it. (§1, §5)
- ☐ Curvature assessed and a construction rated for that bend radius chosen. (§3)
- ☐ Thickness envelope established: 1.5 mm label, ferrite-thin, or rigid tag. (§2.4)
- ☐ Environment profile written down: temperature, wash-down, solvents, UV, abrasion. (§3)
- ☐ Attachment method chosen and drilling permission confirmed where relevant. (§3)

Encoding capability

- ☐ Encoding route decided against Table 3 — printer, desktop bench, handheld, or pre-encoded. (§4)
- ☐ Printer-encoder's maximum media thickness confirmed against the label class, if printing in-house. (§2.4, §4)
- ☐ Chip family confirmed present on the encoder's supported firmware list. (§4)
- ☐ Inlay placement dimensions (a / x / y) documented by the converter, with tolerances. (§4)
- ☐ Whether the media is pre-encoded or locked established, with access passwords obtained. (§4)

Media specification and repeatability

- ☐ Layer-stack datasheet obtained: spacer or ferrite type and thickness, facestock, adhesive, service temperature. (§2.5)
- ☐ Batch record per delivery agreed, naming the inlay lot, the converter and the conversion date. (§2.5)
- ☐ Encode-and-verify sample from the middle of the roll made a condition of every delivery, not just the first. (§2.5)
- ☐ Thickness measured on receipt rather than taken on trust. (§2.5)
- ☐ Understood that a third-party inlay certificate, where one exists, does not extend to the converted label — and that your own validation record is the quality evidence on this programme. (§5)

Validation

- ☐ Read tests performed on production-representative assets, never in free air. (§1.3, §5)
- ☐ Orientation and reader position recorded for every measurement. (§5)
- ☐ Requirement written against the worst realistic case, with margin. (§5)
- ☐ Several asset units tested, not one. (§5)
- ☐ Re-test scheduled after the first real environmental exposure. (§5)
- ☐ Validation record archived as the reference for future claims. (§5)

References

Technical claims in this guide trace to the following sources.

Engineering literature

1. K. Finkenzeller, *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication*, 3rd ed., Wiley, 2010 — coupling, propagation and the behaviour of antennas near conducting surfaces.
2. C. A. Balanis, *Antenna Theory: Analysis and Design* — image theory for antennas near conducting planes, patch-antenna geometry and polarisation, the basis of §1.1, §2.1 and §2.3.
3. ISO/IEC 18000-63 (EPCglobal Class-1 Generation-2) — the air interface assumed throughout.

Component and deployment documentation

4. On-metal tag and label manufacturer specifications — construction classes, thickness classes of roughly 1.3–1.5 mm for flexible labels, ferrite alternatives, attachment methods and temperature ratings. The basis of Table 1. Products vary; the current manufacturer datasheet governs.
5. UHF tag IC datasheets and consolidated comparison tables (Impinj, NXP, Alien Technology, EM Microelectronic and others) — chip memory and sensitivity figures referenced in §3.
6. Printer-encoder manufacturers' media specifications — standard media thickness ranges of roughly 0.06–0.25 mm, on-metal media classes up to approximately 1.5 mm, inlay placement geometry (a / x / y with ±3 mm tolerances), the rule that media converted to a published guideline needs no RFID calibration, reduced print quality around the chip location, and media storage and electrostatic-discharge guidance. The basis of §2.4, §4 and Table 3.
7. Integrator field reports on asset tagging of metal — range degradation figures for standard inlays on steel, the recovery obtained by separating an inlay from the surface, and the failure patterns in Table 4. Field figures vary with geometry and product and are quoted as ranges.
8. RAIN Alliance deployment guidance — material placement practice and validation methodology, reflected in §5.
9. Inlay manufacturing and converting process documentation — the antenna–bonding–converting sequence, flip-chip and COB bonding routes, adhesive curing as the throughput constraint of bonding, end-of-line culling of rejected units, and the relationship between bonding and converting capacity. The basis of the cost and consistency discussion in §2.5.
10. Third-party inlay performance and quality programmes in the retail supply chain, in particular the ARC programme administered by the Auburn University RFID Lab since 2009 — ARC Specs define the performance requirements an inlay model must meet for a given deployment scenario, and ARC Quality Certification audits an inlay manufacturer's quality management system through a multi-stage review including site visits. Both components address the inlay and its manufacturer rather than the converted label, which is the scope note in §5.

Document control and legal notice

Document control

ITEM	DETAIL
Document ID	JNX-TG-003
Title	Tagging Metal Assets with UHF RFID — A Technical Guide
Edition and date	First edition (V1.1), 11 September 2026
Owner	JNXRFID product marketing
Review cycle	Reviewed when a cited standard is revised, when construction classes in Table 1 change materially, or annually, whichever comes first.
Companion documents	JNX-TG-002, *UHF RFID Printer-Encoders — A Buyer's Technical Guide*.
Feedback	Corrections and challenges are welcome and will be reflected in the next edition: support@jnxrfid.com

Notes on accuracy

Construction thicknesses, temperature ratings and read-range figures are representative values compiled from manufacturer documentation and integrator field reports; they vary between products and across mounting geometries, and the governing document for any specific product is its current datasheet. Regulatory allocations are quoted as commonly applied and are subject to change; confirm current national requirements before deployment.

Legal notice

About JNXRFID

JNXRFID builds desktop and industrial UHF and HF RFID printer-encoders — including models rated to print and encode flexible on-metal labels — and UHF RFID desktop readers. We wrote this guide because on-metal labelling is where asset-tracking programmes most often stall, and because the fix is almost always a specification decision made weeks earlier.

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