

# PMI / XRF / LIBS Alloy Analysis: Eliminating Grade Substitution in China-Origin Metal Procurement | Metal-Asia.pw

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## Why PMI Is the #1 ROI Investment in China Metal Procurement

If I were restricted to a **single non-destructive testing method** for China-origin metal shipments, I would choose **Positive Material Identification (PMI)** without hesitation.

The reason is straightforward: **80% of quality failures in Chinese metal supply** originate from chemical composition non-conformance. Grade substitution of AISI 304 with low-cost AISI 201. Under-alloyed nickel in heat-resistant grades. Absence of molybdenum in material certified as AISI 316L. Fraudulent Mill Test Reports with "perfect" chemical values. PMI resolves each of these issues in **3–10 seconds per test**.

In this technical brief, I detail XRF and LIBS analytical technologies, compare their capabilities, present real case studies from our inspection practice, and outline our PMI inspection programs from inbound verification through pre-shipment confirmation.

## The Core Problem: Grade Fraud in China-Origin Metal Supply

Non-Conformance Statistics — Metal-Asia.pw Inspection Data (2023–2026)

Product Category	Lots with Chemical Deviations	Typical Deviations	Downstream Consequences
Stainless Steel AISI 304 (08Cr18Ni10)	22%	Ni 15–30% below spec, elevated Mn	Corrosion in aggressive media, equipment failure
Stainless Steel AISI 316L (03Cr17Ni14Mo3)	28%	Mo absent or <1.5%	Pitting corrosion in chloride environments
Heat-Resistant Alloys (GH4169, Inconel, Haynes)	35%	Ni, Cr, Ti, Al non-conformance	Failure under elevated-temperature service
Structural Steel C45 / 1045, 40Cr / 4140	12%	Low C content, deviant alloying	Insufficient strength, component failure under load
Tool Steels Cr12MoV / D2, T8A / W1-0.8C	18%	Cr, V, C non-conformance	Reduced cutting performance, premature tool wear
Aluminum Alloys 5083-H111, 6061-T6	15%	Mg, Cu, Mn non-conformance	Strength reduction, weldability issues

## Top 5 Fraud Patterns in Chinese Metal Supply

- Visual Clone Substitution.** Supplier ships AISI 201 as AISI 304 — visually indistinguishable, price differential \$400–600/MT captured by the vendor.
- Mill Test Report (MTR) Forgery.** Professional-looking certificates with fabricated chemical data bearing no relation to actual material.
- "Sandwich" Coil Construction.** Outer wraps meet specification; inner wraps are lower-grade material.
- Unauthorized Mill Substitution.** Contract names Mill A; shipment originates from an unqualified mini-mill (Mill B).
- Strategic Under-Alloying.** Deficiency in expensive elements — Ni, Mo, Co — where content directly drives material cost.

## PMI (Positive Material Identification): Method Overview

PMI is the rapid determination of chemical composition to verify that a metallic material conforms to its specified alloy grade. PMI is mandatory across oil & gas, chemical processing, power generation, aerospace, and structural fabrication sectors.

Applications:

- Incoming material verification (raw materials & components)
- Compliance with API RP 578 (Material Verification Program)
- In-service inspection of installed equipment
- Sulfidation corrosion assessment (API RP 939-C)
- Scrap metal sorting and secondary material processing
- [Customs verification for specialty alloy imports](#)

## XRF vs LIBS: Technology Selection Guide

Two primary portable PMI technologies exist: **XRF (X-Ray Fluorescence)** and **LIBS (Laser-Induced Breakdown Spectroscopy)**. Each has distinct strengths; an optimally equipped inspection team carries both instruments.

Comparative Technical Matrix: XRF vs LIBS

Parameter	XRF	LIBS
<b>Operating Principle</b>	Excitation of atoms by primary X-rays; detection of secondary fluorescence	Laser pulse creates plasma (breakdown); optical emission spectroscopy of plasma
<b>Light Elements (C, Si, Al, Mg, S, P)</b>	Limited sensitivity. <b>Carbon (C) cannot be determined</b>	<b>Excellent sensitivity. Carbon in 1–3 seconds</b>
<b>Heavy Elements (Ni, Cr, Mo, Cu, Nb, W)</b>	<b>High accuracy (<math>\pm 0.01</math>–<math>0.05\%</math>)</b>	Good accuracy; marginally inferior to XRF on heavy elements
<b>Analysis Time</b>	5–30 seconds	<b>1–3 seconds</b>
<b>Radiation Safety</b>	Ionizing radiation. Requires training, dosimetric monitoring	<b>Safe. Laser Class 1M/3B</b>
<b>Licensing / Registration</b>	Registration required with national radiation safety authorities (e.g., NRC in USA)	<b>No licensing required</b>
<b>Surface Preparation</b>	Minimal (paint/rust removal)	Requires grinding to "white metal"
<b>Surface Damage</b>	None (fully non-destructive)	Microscopic ignition spot (~50–100 $\mu\text{m}$ )
<b>Aluminum &amp; Magnesium Alloys</b>	Challenges with light elements	<b>Excellent results with Al, Mg, Ti</b>
<b>Analyzer Cost</b>	\$15,000–45,000	\$18,000–35,000
<b>Recommended Models</b>	Vanta Series, X-MET8000, EXPLORER 5000	Vulcan+, mPulse+, Z-200 C+

Application Matrix: Which Instrument for Which Task

Task	Recommended Technology	Rationale
Differentiating AISI 304 / 316L / 321	<b>LIBS</b>	Requires C and Mo determination
Carbon steel verification (S235JR, C45, 4140)	<b>LIBS</b>	Carbon measurement is critical

Task	Recommended Technology	Rationale
Ni-based heat-resistant alloy verification (Inconel, Haynes)	<b>XRF</b>	Precise Ni, Cr, Ti, Al measurement
Stainless scrap sorting	<b>LIBS</b>	Speed + carbon capability
Aluminum alloy analysis (5083, 6061, 7075)	<b>LIBS</b>	Light elements Mg, Si
Copper alloy analysis (bronze, brass)	<b>XRF</b>	Precision on Cu, Sn, Zn, Pb
Pipeline compliance to API 5L (X52, X65, X70)	<b>LIBS</b>	C, S, P determination required

## PMI Analyzer Equipment: Technical Specifications

Table 3. Recommended Portable Analyzers for PMI Field Inspection

Model	Manufacturer	Technology	Element Range	Analysis Time	Weight	Ingress Protection	Price (USD)	Key Features
<b>Vanta Element</b>	Evident (ex-Olympus)	XRF	Mg-U	5-20 sec	1.54 kg	IP54, MIL-STD-810G	~\$15,000	Optimal price/performance for basic PMI
<b>Vanta Core</b>	Evident	XRF	Mg-U	3-15 sec	1.54 kg	IP54, MIL-STD-810G	~\$22,000	Enhanced detector; improved light-element performance
<b>X-MET8000 Optimum</b>	Hitachi	XRF	Mg-U	5-20 sec	1.5 kg	IP54, MIL-STD-810G	~\$28,000	Extensive alloy database; excellent precision
<b>EXPLORER 5000</b>	Skyray	XRF	Na-U	5-30 sec	1.7 kg	IP54	~\$12,000	Budget option; strong GOST/ASTM database
<b>Vulcan+</b>	Hitachi	LIBS	C-U (incl. C, S, P, Si, Al, Mg)	<b>1-3 sec</b>	1.5 kg	IP54, MIL-STD-810G, sapphire window	~\$20,000	<b>Flagship LIBS. Best for carbon steels</b>
<b>Vulcan Expert</b>	Hitachi	LIBS	C-U	1-3 sec	1.5 kg	IP54, MIL-STD-810G	~\$28,000	Extended alloy library; aluminum mode
<b>mPulse+</b>	Oxford Instruments	LIBS	C-U	1-3 sec	1.3 kg	IP54	~\$18,000	First handheld LIBS on market; proven reliability
<b>Z-200 C+</b>	SciAps	LIBS	C-U + Li, Be, B	1-3 sec	1.8 kg	IP54, MIL-STD-810G	~\$25,000	Unique Li, Be capability

## Metal-Asia.pw PMI Inspection Programs

### Inspection Levels

Level	Sampling Rate	Scope	Cost	Recommended For
<b>Basic PMI</b>	1 test per 5 MT	Single-point PMI per bundle/coil/pipe batch	\$150 base + \$2/test	Carbon steel, structural grades
<b>Standard PMI</b>	1 test per MT	3-point PMI per item (start, middle, end)	\$250 + \$1.50/test	<a href="#">Stainless steel products</a> , galvanized stock
<b>Extended PMI</b>	100% of marked items	Per-bundle/coil PMI + MTR cross-check + photo report	\$400 + \$1/test	Special alloys, heat-resistant grades, OG piping
<b>Premium PMI+NDT</b>	100% + sampling UT	Full PMI + UT for laminations + thickness gauging + Level II report	\$800 + \$0.80/test + \$150/hr UT	Critical lots, defense, nuclear energy

#### Standard PMI Inspection Protocol:

1. **Visual examination** of marking, packaging, and shipping documents
2. **Sample extraction** per AQL methodology or 100% inspection
3. **PMI testing** via portable XRF and/or LIBS analyzer
4. **Cross-reference** against specification and standard (GOST, ASTM, EN, JIS)
5. **Photographic documentation** of each test with item location reference
6. **PMI Report preparation** with conformance / non-conformance determination
7. **Disposition recommendation** — accept, sort, reject, return

## HS Codes for PMI-Controlled Products

Table 4. Customs HS Codes for Alloys & Specialty Steels

Product	HS Code	Import Duty (from China)	PMI Required	Fraud Risk
Stainless steel ingots, ≥2.5% Ni	7218.91.10	5%	Mandatory	High
Other stainless steel, forged square	7218.99.19	5%	Mandatory	High
Stainless cold-rolled sheet/coil	7219	5–10%	Mandatory	High
Stainless hot-rolled sheet/coil	7220	5–10%	Mandatory	High
Stainless steel bars & sections	7222	5–10%	Mandatory	High
Stainless steel wire	7223.00	5%	Mandatory	Medium
Other alloy steel bars	7228	5%	Recommended	Medium
Tool steels	7228.50	5%	Mandatory	Medium
Seamless stainless pipes	7304.41	5–10%	Mandatory	High
Welded stainless pipes	7306.40	5–10%	Mandatory	High
Stainless fittings & flanges	7307.21	5–10%	Mandatory	Medium

## Case Studies — Metal-Asia.pw Field Inspection Practice

### Case 1. AISI 316L Shipment for Chemical Processing (Middle East)

**Background:** Client procured 40 MT AISI 316L (03Cr17Ni14Mo3) tubes for heat exchanger rebuild. Supplier from Jiangsu provided full documentation: MTR, ISO certificate, packing list.

**Our PMI Inspection (Pre-Shipment):** LIBS analysis with Vulcan+ identified:

- Mo content: **0.82%** vs. specified 2.0–3.0%
- Ni content: **6.1%** vs. specified 10–14%

- Cr content: **14.8%** vs. specified 16–18%

**Verdict:** Material corresponded to AISI 201 (low-grade variant), not AISI 316L. **Lot rejected.** Client avoided ~\$180,000 in replacement and downtime costs.

## Case 2. Heat-Resistant Alloy GH4169 for Power Generation (EU)

**Background:** 12 MT GH4169 (Inconel 718 equivalent) bars for gas turbine blade manufacturing.

### Our PMI + XRF Inspection:

- Ni content: **52%** vs. required 50–55% (acceptable)
- Nb + Ta content: **3.8%** vs. required 4.75–5.50% — **below minimum**
- Ti content: **0.6%** vs. required 0.65–1.15% — **below minimum**

**Verdict:** Under-alloyed material that would fail elevated-temperature creep requirements. Lot rejected, supplier replaced.

## Case 3. C45 Structural Steel for Machine Building

**Background:** 80 MT C45 round bar for shaft and axle production.

### Our LIBS Inspection:

- C content: **0.28%** vs. specified 0.42–0.50%
- Material effectively corresponded to C25–C30 grade

**Verdict:** 25–30% strength reduction. Lot directed to sorting; non-conforming bundles returned to mill.

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## ROI Summary: Why PMI Pays for Itself 50–100x Over

PMI inspection cost for a typical 50–100 MT metal shipment: **\$300–800**.

Cost of using fraudulent material: **\$30,000–500,000+** (production shutdown, demolition, litigation, safety incidents).

**PMI is insurance that pays for itself on the very first shipment.**

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## Related Services & Catalog Links

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  - [Stainless Steel Products](#)
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