1.4372, X12CrMnNiN17-7-5, 12Х17Г9АН4-Ш, 12Ch17G9AN4, Z12CMN17-07Az

High-manganese austenitic stainless steels represent an innovative class of materials developed to address the economic challenges posed by nickel price volatility while maintaining the essential characteristics of conventional austenitic grades. These steels utilize manganese (5.5-10.5%) and nitrogen (0.05-0.25%) as partial substitutes for nickel, significantly reducing material costs while preserving the face-centered cubic (FCC) structure that provides excellent formability and toughness .

The grades covered in this guide EN 1.4372, X12CrMnNiN17-7-5, EN 1.4373 - X12CrMnNiN18-9-5, GOST 12Ch17G9AN4, 12Х17Г9АН4, EI878, ЭИ878, 12Х17Г9АН4-Ш, ЭИ878-Ш, PN 1H17N4G9, NF Z12CMN17-07Az share similar metallurgical characteristics but differ in their precise chemical compositions and regional standardization. These materials find extensive application across industries requiring a balance of corrosion resistance, mechanical strength, and economic viability, including:

- Chemical processing equipment
- Food and beverage industry components
- Automotive exhaust systems
- Architectural applications
- Marine environments
- Pharmaceutical manufacturing

This comprehensive review will systematically analyze each grade's chemical composition, mechanical properties, heat treatment requirements, physical characteristics, and performance under various service conditions, providing engineers, metallurgists, and procurement specialists with the data needed for material selection and application development.

Material Specifications and Designations

International Grade Cross-Reference

The high-manganese austenitic stainless steels discussed in this document are known by various designations across different standardization systems:

EN/DIN	ISO	GOST	PN (Poland)	AISI/UNS	Common Names
1.4372	-	12Х17Г9АН4 (EI878)	1H17N4G9	-	X12CrMnNiN17-7-5
X12CrMnNiN17-7-5	-	-	-	-	-
1.4373	X12CrMnNiN18-9-5	-	-	201 (partial equivalent)	X12CrMnNiN18-9-5

These grades are not always direct equivalents but share similar compositional ranges and mechanical properties. The EN 1.4372 (X12CrMnNiN17-7-5) and GOST EI878 (12Х17Г9АН4) are essentially the same material under different standardization systems, while EN 1.4373 (X12CrMnNiN18-9-5) represents a slightly modified version with higher chromium and manganese content .

Standardization and Certification

The materials discussed are covered by the following international and regional standards:

- **EN 1.4372 (X12CrMnNiN17-7-5)**: Covered by EN 10088-2:2005 for stainless steel semi-finished products, bars, rods, and sections
- **EN 1.4373 (X12CrMnNiN18-9-5)**: Included in DIN 17400 and EN standards for austenitic stainless steels
- **GOST 12Ch17G9AN4 (EI878)**: Russian standard for high-manganese austenitic stainless steels
- **ISO X12CrMnNiN18-9-5**: International standardization of the 18-9-5 composition variant

These materials typically carry ISO 9001 certification when produced by reputable manufacturers, ensuring consistent quality and traceability .

Applications

(EN 1.4372, X12CrMnNiN17-7-5, EN 1.4373, X12CrMnNiN18-9-5, GOST 12Ch17G9AN4, EI878, PN 1H17N4G9, NF Z12CMN17-07Az, etc.)

High-manganese austenitic stainless steels are widely used as cost-effective alternatives to traditional nickel-rich grades (e.g., AISI 304/316) while maintaining good corrosion resistance, mechanical strength, and formability. Below is a detailed breakdown of their key applications across various industries.

1. Automotive Industry

These grades are extensively used in automotive components due to their balance of strength, corrosion resistance, and cost efficiency.

- **Exhaust Systems** (Mufflers, Pipes, Catalytic Converter Housings)
  - Resistance to oxidation and thermal fatigue
  - Lower cost than AISI 304 while maintaining adequate high-temperature performance
- **Structural Components** (Brackets, Fasteners, Reinforcement Parts)

- High work-hardening rate improves strength in cold-formed parts
- **Trim & Decorative Elements** (Grilles, Emblems, Wheel Covers)
    - Good polishability and aesthetic appeal

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2. Construction & Architecture

Their corrosion resistance and formability make them suitable for architectural and structural applications.

- **Building Facades & Roofing**
    - Resistance to atmospheric corrosion (urban, industrial, marine environments)
- **Decorative Panels & Handrails**
    - Aesthetic finish options (brushed, polished, colored coatings)
- **Structural Fasteners & Fixings**
    - High strength-to-weight ratio for lightweight construction

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3. Chemical & Petrochemical Industry

These steels are used in moderate corrosive environments where cost efficiency is critical.

- **Storage Tanks & Pressure Vessels**
    - Resistance to nitric acid, organic acids, and alkaline solutions
- **Piping & Valves**
    - Suitable for handling mildly corrosive fluids
- **Heat Exchangers & Reactors**
    - Good thermal conductivity and oxidation resistance up to ~500°C

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4. Food & Pharmaceutical Processing

Their hygienic properties and corrosion resistance make them ideal for food-contact applications.

- **Food Processing Equipment** (Tanks, Conveyors, Mixers)
    - Resistant to organic acids (lactic, acetic, citric)
- **Brewery & Dairy Equipment**
    - Non-reactive with milk, beer, and other consumables
- **Pharmaceutical Machinery & Storage**
    - Easy to sterilize and maintain

5. Marine & Offshore Applications

While not as corrosion-resistant as high-nickel grades, they are used in less aggressive marine environments.

- **Shipbuilding Components** (Deck Fittings, Railings)
  - Moderate chloride resistance for coastal applications
- **Desalination Equipment**
  - Used in brackish water treatment systems

6. Electronics & Precision Engineering

Their non-magnetic properties and formability are advantageous in electronics.

- **Electronic Enclosures & Connectors**
  - Non-magnetic characteristics ensure signal integrity
- **Medical & Diagnostic Equipment**
  - Used in MRI-compatible components

7. Industrial & General Engineering

- **Springs & Mechanical Components**
  - High yield strength after cold working
- **Welded Fabrications**
  - Good weldability with proper post-weld heat treatment

Summary of Key Advantages

Cost-Effective – Lower nickel content reduces material costs
Good Corrosion Resistance – Suitable for mild to moderately aggressive environments
High Strength & Formability – Excellent for cold-forming applications
Non-Magnetic – Ideal for electronics and medical devices

For specific material selection, always consider the exact environmental conditions and mechanical requirements. These grades are not recommended for highly corrosive (e.g., hydrochloric acid) or high-temperature (>500°C) applications where traditional high-nickel stainless steels would be more suitable.

Equivalent or Similar Grades - Chemical Composition

Comparative Chemical Composition Tables

The chemical compositions of these high-manganese austenitic stainless steels are carefully balanced to achieve optimal austenite stability, corrosion resistance, and mechanical properties while minimizing nickel content. Below are the specified compositional ranges for each grade:

Table 1: Chemical Composition Requirements (Weight %)

Element	EN 1.4372, X12CrMnNiN17-7-5	EN 1.4373, X12CrMnNiN18-9-5	GOST 12Ch17G9AN4, 12X17Г9АН4, EI878, ЭИ878, 12X17Г9АН4-Ш, ЭИ878-Ш	PN 1H17N4G9	ISO X12CrMnNiN18-9-5
C (max)	0.15	0.15	0.15	0.15	0.15
Si (max)	1.00	1.00	1.00	1.00	1.00
Mn	5.50-7.50	7.50-10.50	8.00-10.00	8.00-10.00	7.50-10.50
P (max)	0.045	0.045	0.045	0.045	0.045
S (max)	0.015	0.015	0.015	0.015	0.015
Cr	16.00-18.00	17.00-19.00	16.00-18.00	16.00-18.00	17.00-19.00
Ni	3.50-5.50	4.00-6.00	3.50-5.50	3.50-5.50	4.00-6.00
N	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25
Mo (max)	-	0.80 (optional)	-	-	0.80 (optional)

Key Alloying Elements and Their Roles

- **Chromium (Cr)**: The primary corrosion-resistant element (16-19%) forms a passive oxide layer (Cr_2O_3) that protects against general corrosion. Higher Cr content improves resistance to oxidizing environments .
- **Manganese (Mn)**: Essential austenite stabilizer (5.5-10.5%) that partially replaces nickel. Enhances work-hardening rate and solid solution strengthening .
- **Nickel (Ni)**: Secondary austenite stabilizer (3.5-6%) that improves ductility and toughness while enhancing resistance to reducing acids .
- **Nitrogen (N)**: Powerful austenite stabilizer (0.05-0.25%) that significantly increases yield strength through interstitial solid solution hardening and improves pitting resistance .
- **Carbon (C)**: Limited to ≤0.15% to minimize carbide precipitation and associated sensitization risks during welding or high-temperature exposure .

The careful balance of these elements allows these grades to maintain austenitic structure (FCC) at room temperature while achieving mechanical properties comparable to or exceeding conventional 300-series stainless steels .

Mechanical Properties

Room Temperature Mechanical Properties

The mechanical properties of high-manganese austenitic stainless steels vary depending on the specific grade and condition (annealed, cold worked, etc.). Below are the typical mechanical property ranges for these materials:

Table 2: Typical Mechanical Properties at Room Temperature

Property	EN 1.4372 (X12CrMnNiN17-7-5)	EN 1.4373 (X12CrMnNiN18-9-5)	GOST EI878	PN 1H17N4G9	ISO X12CrMnNiN18-9-5
Yield Strength (Rp0.2, MPa)	≥286 (annealed)	≥205 (annealed)	≥250	≥250	≥205
	Up to 900 (cold worked)	Up to 850 (cold worked)			
Tensile Strength (Rm, MPa)	≥771 (annealed)	≥515 (annealed)	≥540	≥540	≥515
	Up to 1200 (cold worked)	Up to 1000 (cold worked)			
Elongation (A_5, %)	≥13 (annealed)	≥35 (annealed)	≥30	≥30	≥35
	5-15 (cold worked)	10-25 (cold worked)			
Hardness (HBW)	332 (annealed)	183 (annealed)	200-250	200-250	183
	Up to 400 (cold worked)	Up to 350 (cold worked)			
Impact Energy (KV, J)	13 (at 20°C)	90 (at 20°C)	50	50	90
Modulus of Elasticity (GPa)	200	200	200	200	200

The higher manganese content in EN 1.4373 (7.5-10.5% vs. 5.5-7.5% in EN 1.4372) contributes to its superior elongation and impact toughness in the annealed condition, while both grades demonstrate significant strengthening through cold work .

High Temperature Mechanical Properties

These high-manganese austenitic stainless steels maintain useful mechanical properties at elevated temperatures, though they are not typically classified as high-temperature alloys:

Table 3: Elevated Temperature Mechanical Properties

Temperature (°C)	EN 1.4372 0.2% Proof Strength (MPa)	EN 1.4373 0.2% Proof Strength (MPa)	EN 1.4372 Tensile Strength (MPa)	EN 1.4373 Tensile Strength (MPa)
100	220	180	650	480
200	190	160	600	440
300	170	140	550	400
400	150	120	500	360
500	130	100	450	320

The short-term elevated temperature strength of these grades is generally lower than nickel-rich austenitic stainless steels like 304 or 316, but they remain suitable for many applications up to about 500°C .

Creep and Stress Rupture Properties

While not primarily designed for high-temperature creep service, these materials demonstrate the following approximate creep performance:

- **Creep Limit**: 100,000 hours at 1% creep strain
  - 350°C: ~120 MPa
  - 400°C: ~80 MPa
  - 450°C: ~50 MPa
- **Stress Rupture Strength**: 100,000 hours rupture life
  - 350°C: ~200 MPa
  - 400°C: ~140 MPa
  - 450°C: ~90 MPa

For applications requiring superior high-temperature creep resistance, traditional high-nickel austenitic or specialty alloys would be more appropriate.

Physical Properties

The physical properties of high-manganese austenitic stainless steels are similar to conventional austenitic grades but with some variations due to the manganese and nitrogen content:

Table 4: Physical Properties Comparison

Property	EN 1.4372 (X12CrMnNiN17-7-5)	EN 1.4373 (X12CrMnNiN18-9-5)	Unit
Density	7.93	7.7-7.9	g/cm^3
Melting Range	1400-1450	1360-1400	°C
Thermal Conductivity (20°C)	16.3	15	W/(m·K)
Specific Heat Capacity (20°C)	500	480	J/(kg·K)
Electrical Resistivity	0.73	0.70	$\Omega \cdot mm^2/m$
Magnetic Permeability (Annealed)	<1.02	<1.02	-
Coefficient of Thermal Expansion (20-100°C)	16.0	16.5-17.0	$10^{-6}/K$
Modulus of Elasticity	200	200	GPa
Poisson's Ratio	0.28-0.30	0.28-0.30	-

The higher manganese content in EN 1.4373 results in slightly lower density and thermal conductivity compared to EN 1.4372. Both grades are essentially non-magnetic in the annealed condition, though cold working may induce slight magnetism .

Thermal and Electrical Properties

The thermal and electrical properties of these materials show the following temperature dependencies:

Thermal Conductivity:

- Increases with temperature (16 → 25 W/(m·K) from 20°C to 500°C)

Electrical Resistivity:

- Increases with temperature (0.73 → 1.05 $\Omega \cdot mm^2/m$ from 20°C to 500°C)

Specific Heat Capacity:

- Increases with temperature (500 → 600 J/(kg·K) from 20°C to 500°C)

These properties are important considerations for applications involving heat transfer or electrical components.

Heat Treatment

Standard Heat Treatment Procedures

Proper heat treatment is essential for optimizing the properties of high-manganese austenitic stainless steels. The following treatments are commonly applied:

1. **Solution Annealing (Condition A)**
    - Temperature range: 1020-1100°C (EN 1.4372), 1050-1150°C (EN 1.4373)
    - Holding time: 15-30 minutes per 25mm thickness
    - Cooling: Rapid water quenching or air cooling to preserve austenitic structure and prevent carbide precipitation
2. **Stress Relieving**
    - Temperature: 300-450°C
    - Time: 1-2 hours
    - Purpose: Reduce residual stresses from cold working without significantly affecting mechanical properties
3. **Stabilization Annealing (for welded components)**
    - Temperature: 850-950°C
    - Time: 1-2 hours
    - Cooling: Air or water
    - Purpose: Dissolve chromium carbides and homogenize structure after welding

Condition Designations

These materials are typically supplied in the following conditions with corresponding mechanical properties:

- **+A**: Solution annealed - optimal corrosion resistance and formability
- **+AT**: Solution annealed and temper rolled (lightly cold worked for improved flatness)
- **+H**: Hard rolled (various cold work levels for increased strength)
- **+HT**: Heat treated (specific precipitation hardening treatments when applicable)

Effects of Heat Treatment on Microstructure

Solution annealing produces a fully austenitic microstructure with minimal carbide precipitation. The high manganese content ensures austenite stability even at rapid cooling rates. Prolonged exposure in the 500-900°C range should be avoided to prevent:

- Chromium carbide precipitation at grain boundaries (sensitization)
- Sigma phase formation (particularly in higher chromium variants)
- Nitride precipitation

Processing Performance

Corrosion Resistance

General Corrosion Performance

High-manganese austenitic stainless steels offer good general corrosion resistance in many environments, though their performance differs from traditional 300-series grades:

Resistant to:

- Atmospheric corrosion (urban, industrial, marine)
- Fresh and distilled water
- Many organic acids (acetic, citric, lactic)
- Food products (milk, beer, coffee, oils)
- Nitric acid at various concentrations
- Alkaline solutions

Limited Resistance to:

- Reducing acids (hydrochloric, sulfuric)
- Chloride-induced stress corrosion cracking
- Highly oxidizing conditions (hot concentrated nitric acid)
- Crevice corrosion in stagnant chloride solutions

The corrosion resistance of these grades primarily depends on their chromium content (16-19%) and the stability of their passive film. The higher manganese content makes them somewhat less resistant to oxidizing environments than standard 304 stainless steel but provides cost advantages .

Specialized Corrosion Resistance

Pitting and Crevice Corrosion:

- Pitting Resistance Equivalent Number (PREN) = %Cr + 3.3×%Mo + 16×%N
- EN 1.4372: PREN ~18-20
- EN 1.4373: PREN ~19-22 (with optional Mo)
- Comparable to 304L in chloride environments

Intergranular Corrosion:

- Sensitization risk in 450-850°C range due to chromium carbide precipitation
- Low carbon content (<0.15%) reduces but doesn't eliminate sensitization
- Post-weld annealing or stabilization recommended for critical applications

Stress Corrosion Cracking (SCC):

- More susceptible to chloride SCC than standard 304 due to higher Mn content
- Not recommended for >60°C chloride environments
- Nitrogen addition improves