1.3816, X8CrMnN18-18, ASTM A289

The selection of 1.3816, X8CrMnN18-18, or ASTM A289 compliant steel for generator retaining rings depends on specific application requirements, with all offering excellent nonmagnetic properties and high strength. X8CrMnN18-18 demonstrates particularly high strength characteristics suitable for the most demanding applications, while SEW 390 serves different but related applications requiring exceptional uniform elongation. Proper heat treatment and processing are critical to achieving the desired performance characteristics in these specialized materials.

Nonmagnetic retaining rings are critical components in large generators (50MW-200MW), serving to constrain the rotor windings against tremendous centrifugal forces during operation. These specialized components require materials with exceptional strength, nonmagnetic properties, and resistance to stress corrosion cracking. Three prominent steel grades used for this application are 1.3816, X8CrMnN18-18, and steels conforming to ASTM A289 specification. This article provides a detailed technical comparison of these materials, covering their chemical compositions, mechanical properties, heat treatment requirements, and performance characteristics under operational conditions.

Cross-reference of similar materials from different standards:

Grade	Equivalent/Similar Grades	Standard
1.3816	X8CrMnN18-18, 18Mn18Cr, P900	EN/DIN
X8CrMnN18-18	1Mn18Cr18N, 50Mn18Cr5, 50Mn18Cr4W	Various
ASTM A289	Custom formulations meeting specification requirements	ASTM
SEW 390	API 5CT-95ksi, P110 (after expansion)	API

Note: While some grades may have similar compositions, exact equivalents may not exist due to proprietary processing requirements .

Retaining ring materials undergo rigorous quality control:

- **Chemical Analysis:** Verification of composition
- **Mechanical Testing:** Tensile, impact, hardness
- **Non-Destructive Testing:** UT (ASTM A531 Lever 2), PT (ASTM E165)
- **Metallographic Examination:** Grain size (ASTM E112), cleanliness (ASTM E45)
- **Magnetic Permeability Testing:** ≤1.03 (ASTM A342)

Applications

These materials are specifically designed for demanding generator applications:

1.3816 and X8CrMnN18-18

- Large turbine generator retaining rings (50MW-200MW range)
- Nuclear power generator components
- High-speed rotating equipment where nonmagnetic properties are critical

ASTM A289 Compliant Steels

- Nonmagnetic retaining rings for generators
- Critical rotating components in power generation equipment
- Applications requiring high strength and low magnetic permeability

SEW 390

- Expansion tubes for oil/gas applications
- Well casing applications
- Where high uniform elongation is required

Equivalent or Similar Grades - Chemical Composition

The chemical compositions of these nonmagnetic retaining ring steels are carefully balanced to achieve the required mechanical properties while maintaining low magnetic permeability:

Element	1.3816	X8CrMnN18-18	ASTM A289	SEW 390
C	0.08-0.25%	0.08-0.25%	0.08-0.25%	0.08-0.25%
Mn	17.0-19.0%	17.0-19.0%	17.0-19.0%	17.0-19.0%
Cr	17.0-19.0%	17.0-19.0%	17.0-19.0%	17.0-19.0%
Ni	-	-	-	0.1-0.6%
N	0.40-0.60%	0.40-0.60%	-	-
Mo	-	-	-	0.1-0.6%
Si	≤1.00%	≤1.00%	≤1.00%	≤1.00%
P	≤0.040%	≤0.040%	≤0.040%	≤0.040%
S	≤0.030%	≤0.030%	≤0.030%	≤0.030%
Cu	-	-	-	0.1-0.6%
Nb	-	-	-	0.01-0.06%
B	-	-	-	0.001-0.003%

Note: ASTM A289 allows for some variation in composition based on specific manufacturer

formulations while maintaining nonmagnetic properties . SEW 390 includes additional microalloying elements for enhanced performance .

Mechanical Properties

The mechanical properties of these materials are critical for their performance in generator applications:

Mechanical properties acc. to ASTM A289/A289M

Grade 1

- Tensile strength ksi/MPa: min 145/1000
- 0.2% Offset Yield Strength Psi/MPa: Min 135/930
- Elongation in 2 in. or 50mm, min 28%
- Reduction of Area, min 60%
- Charpy V-Notch Energy, min. ft/lb/J: 70/95

Grade 2

- Tensile strength ksi/MPa: min 155/1070
- 0.2% Offset Yield Strength Psi/MPa: Min 145/1000
- Elongation in 2 in. or 50mm, min 25%
- Reduction of Area, min 55%
- Charpy V-Notch Energy, min. ft/lb/J: 65/88

Grade 3

- Tensile strength ksi/MPa: min 165/1140
- 0.2% Offset Yield Strength Psi/MPa: Min 160/1105
- Elongation in 2 in. or 50mm, min 20%
- Reduction of Area, min 50%
- Charpy V-Notch Energy, min. ft/lb/J: 60/81

Grade 4

- Tensile strength ksi/MPa: min 170/1170
- 0.2% Offset Yield Strength Psi/MPa: Min 165/1140
- Elongation in 2 in. or 50mm, min 19%
- Reduction of Area, min 48%
- Charpy V-Notch Energy, min. ft/lb/J: 58/79

Grade 5

- Tensile strength ksi/MPa: min 175/1205
- 0.2% Offset Yield Strength Psi/MPa: Min 170/1170
- Elongation in 2 in. or 50mm, min 17%
- Reduction of Area, min 45%
- Charpy V-Notch Energy, min. ft/lb/J: 55/75

Grade 6

- Tensile strength ksi/MPa: min 185/1275
- 0.2% Offset Yield Strength Psi/MPa: Min 180/1240
- Elongation in 2 in. or 50mm, min 14%
- Reduction of Area, min 40%
- Charpy V-Notch Energy, min. ft/lb/J: 50/68

Grade 7

- Tensile strength ksi/MPa: min 195/1345
- 0.2% Offset Yield Strength Psi/MPa: Min 190/1310
- Elongation in 2 in. or 50mm, min 12%
- Reduction of Area, min 35%
- Charpy V-Notch Energy, min. ft/lb/J: 40/54

Grade 8

- Tensile strength ksi/MPa: min 200/1380
- 0.2% Offset Yield Strength Psi/MPa: Min 195/1345
- Elongation in 2 in. or 50mm, min 10%
- Reduction of Area, min 30%
- Charpy V-Notch Energy, min. ft/lb/J: 35/47

Property	**1.3816**	**X8CrMnN18-18**	**ASTM A289 Requirements**	**SEW 390**
Yield Strength (Rp0.2)	≥1000 MPa	1000-1240 MPa	≥1000 MPa	480-670 MPa
Tensile Strength (Rm)	1040-1240 MPa	1040-1240 MPa	≥1000 MPa	650-900 MPa
Elongation (A)	≥22%	≥22%	≥22%	30-43%
Reduction of Area (Z)	≥44%	≥44%	≥44%	-
Impact Energy (Charpy V, 20°C)	≥90J	≥90J	≥90J	-

Property	1.3816	X8CrMnN18-18	ASTM A289 Requirements	SEW 390
Hardness (HBW)	234	234	≤302	-
Uniform Elongation	-	-	-	≥16%
Magnetic Permeability (μ)	≤1.03	≤1.03	≤1.03	-

Note: X8CrMnN18-18K shows particularly high strength characteristics suitable for large power generators . SEW 390 prioritizes uniform elongation for expansion applications .

High-Temperature Performance and Creep Resistance

For generator applications where retaining rings may experience elevated temperatures:

1.3816 and X8CrMnN18-18:

- Maintain strength up to approximately 300°C
- Good resistance to stress relaxation
- Creep rupture strength at 300°C: ~600 MPa for 1000 hours

ASTM A289 Steels:

- Designed for stable performance under centrifugal loading
- Microstructure optimized for resistance to stress corrosion cracking
- Long-term creep performance validated through industry use

SEW 390:

- Lower high-temperature capability compared to retaining ring steels
- Primarily designed for room temperature expansion applications

Physical Properties

Key physical properties of these nonmagnetic steels:

Property	1.3816/X8CrMnN18-18	ASTM A289 Steels	SEW 390
Density (g/cm³)	7.8	7.8	7.8
Thermal Conductivity (W/m·K)	14.2	-	34.3
Specific Heat Capacity (J/kg·K)	500	-	-
Electrical Resistivity (μΩ·m)	0.85	-	-
Coefficient of Thermal Expansion (10^{-6}/K)	17.5	-	-

Property	1.3816/X8CrMnN18-18	ASTM A289 Steels	SEW 390
Elastic Modulus (GPa)	200	200	200

Heat Treatment

Proper heat treatment is essential to achieve the desired microstructure and mechanical properties:

1.3816 and X8CrMnN18-18:

- **Solution Treatment:** Heating to 1050-1150°C followed by rapid cooling (water quenching) to obtain a fully austenitic structure
- **Cold Working:** Mechanical expansion or other cold working processes to increase strength
- **Stress Relief:** Heating to 350°C ±15°C for 10-12 hours with controlled heating rate ≤40°C/h

ASTM A289 Compliant Steels:

- **Electro-Slag Remelting (ESR):** Required for ingot production to ensure purity
- **Solution Treatment:** Following hot working and prior to cold expansion
- **Cold Expansion:** Performed after rough machining
- **Final Heat Treatment:** May include aging or stress relief as required

SEW 390:

- **HFW Welding:** For pipe formation
- **Thermal Tension Reduction:** Heating to 780-980°C followed by controlled cooling
- **Stress Relief:** 150-300°C for 1-2 hours

Processing Performance

Machinability

- All grades require careful machining due to high strength and work hardening tendency
- Recommended to use carbide tools with positive rake angles
- Adequate cooling required to prevent overheating

Welding

- 1.3816 and X8CrMnN18-18: Generally not recommended for welding due to risk of cracking and property degradation

- ASTM A289: Welding not typical for finished rings; ESR process used for ingot production
- SEW 390: Designed for weldability with HFW (High Frequency Welding) process

Forming

- Cold forming processes used to achieve final dimensions and properties
- Special tooling required due to high strength
- Springback must be accounted for in design