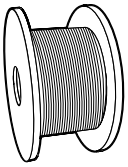
ZAPP PRECISION WIRE
ALLOY MP35N® (UNS R30035) WIRE

QUALITY SYSTEM CERTIFIED TO ISO 9001:2015



ALLOY MP35N® (UNS R30035)

_ For armoring applications on electromechanical cables
_ Wirelines for down hole service applications

Multiphase MP35N® (UNS R30035) is a special quaternary alloy offering excellent corrosion resistance in a wide variety of aggressive, down hole environments. It is especially suitable for sour well conditions. The nominal composition of the alloy is: nickel 35%, cobalt 35%, chromium 20% and molybdenum 10%. The alloy is vacuum induction melted and consumable vacuum arc remelted. Residual elements such as carbon, nitrogen, silicon, sulfur, and phosphorous are maintained at as low a level as possible. Billets are hot rolled to rod, shaved to remove surface defects, annealed, pickled, and then supplied to Zapp for drawing to wire.
The MP35N® alloy was developed as a high strength, ductile material which provides excellent corrosion resistance. It has been found to have outstanding resistance to sour well conditions. The alloy offers excellent resistance to pitting and crevice corrosion. Performance in these areas is often measured using Critical Pitting Temperatures (CPT), Critical Crevice Temperatures (CCT), and Pitting Resistance Equivalent Numbers (PREN). Data is available to show superior values for MP35N®. ASTM Standard Test Methods G 48 is also referenced. It covers the procedures for the determination of the resistance of various alloys to pitting and crevice corrosion.

FOR COMPARISON PURPOSES, PREN AND CPT NUMBERS* ARE REPRESENTED FOR THESE ALLOYS

Alloy	PREN	CPT (°F)	CPT (°C)
316	26	72	22
alloy 2205	36	108	42
XM19	38	106	41
alloy 2507	41	143	61
alloy 28	40	129	54
25-6MO	47	149	65
27-7MO	56	176	80
MP35N®	53	183	84
C276	68	>302	>150

* PREN = Cr + 3.3 Mo + 30N
** CPT (°C) = 2.5 Cr + 7.6 Mo + 31.9 N – 41

It should be noted that the PREN value for MP35N® doesn't reflect the true comparative corrosion resistance compared to 27-7MO. MP35N® contains about 35% cobalt. Cobalt is a critical factor in terms of corrosion resistance and break strength. However, cobalt percentages are not included in the PREN formula and thus tend to skew the relative corrosion resistance results in this instance. Corrosion tests would confirm that MP35N® is superior to 27-7MO.

Chemistry standards:
_ UNS R30035
_ ASTM F562
_ NACE MR0175
_ Alloy No. 909035

LIMITING CHEMICAL COMPOSITION OF MP35N®

Ni	Co	Cr	Mo	C	Mn	Ti	Fe	N
33.00 – 37.00	balance (typically around 33.00)	19.00 – 21.00	9.00 – 10.50	0.025 max.	0.15 max.	1.00 max.	1.00 max.	0.007 max

The chemical balance (especially the nickel and cobalt) provides significantly better resistance to chloride ion stress corrosion cracking than lower nickel alloys. MP35N® wire produces high mechanical properties. Tensile strengths in the order of 270/300,000 psi are achieved through cold drawing. At these strength levels, the wire is ductile and able to successfully pass the wrap test in the as drawn condition as well as the as drawn plus exposed to temperatures as high as 400°F - 500°F conditions. This wrap or bend test shows no surface cracking or failure in either condition.

MP35N® is also identified as UNS R30035. Wire products are partially covered by ASTM F562 and also referenced in the NACE Standard MRO175. Material produced to the UNS R30035 chemistry ranges and manufactured into armor wire or wirelines by Zapp Precision Wire will provide an excellent quality product. Zapp Precision Wire technology, quality, and superior wire drawing capabilities will make the difference for these critical applications.

The Zapp Precision Wire quality system is registered to ISO-9001:2015.

PHYSICAL PROPERTIES OF MP35N® IN ANNEALED CONDITION AT ROOM TEMPERATURE

Density	0.309 [lb/in³]/ 8.55 [g/cm³]
Melting range	2,400 – 2,625 [°F]/ 1,315 – 1,440 [°C]
Electrical resistivity	621 [ohm·circ mil/ft]/ 1.03 [μΩ·m]
Magnetic permeability	1.0009
Specific heat	0.12 [Btu/lb·°F]/ 500[J/kg·°C]
Young´s modulus	33.76 [10^3 Ksi]/ 232.8 [GPa]
Thermal expansion	7.1 [in/in·°F x 10^{-6}]/ 12.78 [cm/cm·°C x 10^{-6}]

ZAPP TECHNICAL DATA

ALLOY CHEMISTRY

Alloy	UNS	C	Mn	Cr	Ni	Mo	Cu	N	Co	Ti	Fe
316	S31600	.08	2.0	16.0 - 18.0	10.0 - 14.0	2.0 - 3.0	-	-	-	-	bal.
2205	S32205	.03	2.0	21.0 - 23.0	4.5 - 6.5	2.5 - 3.5	-	0.18	-	-	bal.
XM19	S20910	.06	4.0 - 6.0	20.5 - 23.5	11.5 - 13.5	1.5 - 3.0	-	0.20 - 0.40	-	-	bal.
2507	S32750	.03	1.2	25.0	7.0	4.0	-	0.30	-	-	bal.
25-6MO	NO8926	.02	2.0	19.0 - 21.0	24.0 - 26.0	6.0 - 7.0	0.5 - 1.5	0.15 - 0.25	-	-	bal.
27-7 MO	S31277	.02	3.0	20.5 - 23.0	26.0 - 28.0	6.6 - 8.0	0.5 - 1.5	0.30 - 0.40	-	-	bal.
MP35N®	R30035	.02	0.1	19.0 - 21.0	33.0 - 37.0	9.0 - 10.5	-	-	bal.	1.0	1.0
C276	N10276	.01	1.0	14.5 - 16.5	-	15.0 - 17.0	-	-	2.5	-	4.0 - 7.0

(Maximum values unless range specified)

ARMOR WIRE TYPICAL TENSILE STRENGTH RANGES (KSI)

Size	316	XM19	25-6MO	27-7MO	MP35N®
0.020" - 0.029"	230/265	250/280	245/275	255/280	275/300
0.030" - 0.066"	225/260	245/280	240/275	255/280	275/300

WIRELINE MINIMUM BREAK STRENGTH**

Size	316	2205	XM19	2507	25-6MO	27-7MO	MP35N	C276
0.082"	1150#	1345#	1215#	1345#	1175#	1300#	1300#	1280#
0.092"	1500#	1690#	1540#	1690#	1500#	1650#	1690#	1615#
0.108"	2000#	2240#	2200#	2240#	2130#	2250#	2300#	2210#
0.125"	2700#	2945#	3000#	2975#	2750#	3000#	3100#	2935#
0.140"	3300#	3540#	3540#	3694#	3250#	3670#	3725#	3680#
0.150"	3750#	3975#	4065#	4150#	3750#	4155#	4240#	4205#
0.160"	4225#	4425#	4625#	4665#	4250#	4650#	4825#	4785#

(** The recommended **safe working load** is 60% of minimum break strength)

DENSITY/CORROSION

Alloy	Density (lb/in³)	Corrosion (PREN)*	CPT (°F)	CPT (°C)**
316	.287	26	72	22
2205	.287	36	108	42
XM19	.285	38	106	41
2507	.281	41	144	62
25-6MO	.290	47	149	65
27-7MO	.289	56	176	80
MP35N®	.309	53	183	84
C276	.321	68	>302	>150

* PREN = Cr + 3.3 Mo+30 N
** CPT (°C) =2.5 Cr + 7.6 Mo + 31.9 N - 41

EXAMPLES OF THEORETICAL ACCEPTABLE WELL ENVIRONMENTS FOR MP35N® WIRE*

Chlorides	Temp °F	H_2S	CO_2	Pressure (PSI)	Req. Minimum Pitting Index (PI)	MP35N® (PI)	MP35N® (PREN)
200,000 ppm	445	15 %	15 %	15,000	50.00	52.18	53
28,000 ppm	435	30 %	25 %	13,000	50.00	52.18	53
120,000 ppm	440	20 %	35 %	15,000	50.00	52.18	53
150,000 ppm	445	30 %	30 %	15,000	50.00	52.18	53
50,000 ppm	449	35 %	45 %	20,000	50.00	52.18	53
20,000 ppm	425	1 %	10 %	15,000	50.00	52.18	53
150,000 ppm	425	3 %	11 %	15,000	50.00	52.18	53
120,000 ppm	425	20 %	30 %	15,000	50.00	52.18	53

* The theoretical acceptable well environments are based on the SOCRATES software. SOCRATES is a comprehensive material selection tool for oil and gas applications that selects corrosion resistant alloys (CRA) through material evaluation based on mechanical strength parameters, heat treatment/cold work and hardness limitations. The program also evaluates the characterization of the environment in terms of operating pressure, temperature, pH, H_2S, chlorides, elemental sulfur, aeration, gas to oil ratio and water to gas ratio water cut. Stress corrosion cracking, hydrogen embrittlement cracking, sulphide stress cracking and resistance to pitting corrosion are also evaluated. The examples above are based on the environment listed and do not take into consideration the actual values of elemental sulfur, aeration, gas to oil ratio and water to gas ratio water cut.

PI= Cr + 3.3Mo + 11N + 1.5(W+Nb)

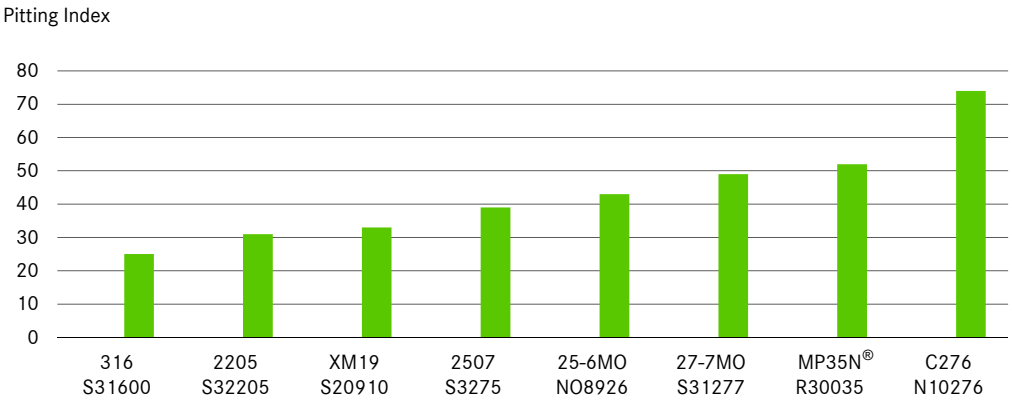
PREN = Cr + 3.3Mo + 30N
It should be noted that the PI and PREN values of MP35N® do not totally reflect its true corrosion resistance because these formulas do not address the cobalt content of MP35N®.

NOTE: The information in the Socrates summary report does not represent a commitment by Honeywell InterCorr International or Zapp Precision Wire, Inc. The information contained in this document and the Socrates software is purely advisory in nature. In no event shall Honeywell InterCorr, Zapp Precision Wire, Inc., or their employees or agents have liability for damages, including but not limited to, consequential damages arising out of or in connection with any person's use or inability to use the information in this document.

NOMINAL CHEMICAL COMPOSITION COMPARISON

Chemical Element	316	2205	XM19	2507	25-6MO	27-7MO	MP35N®	C276
Fe	65.40	67.71	56.40	62.43	46.30	39.65	1.00	5.5
Mn	2.00	2.0	5.00	0.6	2.00	3.00	0.15	0.5
Ni	12.00	5.5	12.50	7.0	25.00	27.00	35.00	55.0 bal.
Co	*	*	*	*	*	*	32.90	2.0
Cr	17.00	22.0	22.00	25.0	20.00	21.75	20.00	15.5
Mo	2.50	2.5	2.25	4.0	6.50	7.25	9.75	16.0
W	*	*	*	*	*	*	*	*
Nb	*	*	0.20	*	*	*	*	*
N	*	0.12	0.30	*	0.20	0.35	*	*
* Trace								
PI	25.25	31.57	33.03	39.85	43.65	49.53	52.18	74.43

MATERIAL SELECTION OVERVIEW



WEIGHT PER FOOT (LBS.) FOR WIRELINES

Alloy	.082"	.092"	.108"	.125"	.140"	.150"	.160"
316	0.018	0.023	0.031	0.042	0.053	0.060	0.069
2205	0.018	0.022	0.031	0.041	0.052	0.059	0.068
XM19	0.018	0.023	0.031	0.042	0.053	0.060	0.069
2507	0.018	0.022	0.031	0.041	0.052	0.059	0.068
25-6MO	0.018	0.023	0.032	0.043	0.054	0.062	0.070
27-7MO	0.018	0.023	0.032	0.043	0.054	0.062	0.070
MP35N®	0.020	0.025	0.034	0.046	0.057	0.066	0.075
C276	0.018	0.022	0.031	0.041	0.052	0.059	0.068

ZAPP PRECISION WIRE STANDARDS

1. All wirelines must pass an eddy current test as part of our NDT quality assurance program.
2. All wirelines and armor wires must pass an aged wrap test as part of our ductility quality assurance program.
3. All wirelines and armor wires have full traceability.
4. All MP35N® wirelines and armor wires are produced using shaved, defect free rod material.

ZAPP PRECISION WIRE QUALITY

The Zapp Precision Wire technology, quality, and superior wire drawing capabilities will make the difference for critical armor wire and wireline applications.

The Zapp Precision Wire quality system is registered to ISO 9001:2015.

ZAPP PRECISION WIRE
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Last revision: July 2018