

CERTIFICATE OF ANALYSIS

IMZ IN 718 PWD

CERTIFIED REFERENCE MATERIAL INCONEL NICKEL ALLOY POWDER FOR ADDITIVE MANUFACTURING

Analysis listed as percent by weight [% m/m]

	Certified value	Expanded uncertainty		Certified value	Expanded uncertainty
Al	0.53	± 0.04	S	0.0025	± 0.0005
C	0.045	± 0.003	Si	0.048	± 0.011
Cr	19.09	± 0.63	Ti	1.04	± 0.07
Cu	0.010	± 0.006	N	0.0150	± 0.0049
Fe	17.17	± 0.83	O	0.0157	± 0.0075
Mn	0.011	± 0.002	Co	(0.012)	
Mo	3.12	± 0.16	H	(0.0007)	
Nb	5.11	± 0.36	V	(0.006)	
Ni	53.85	± 0.86	W	(0.007)	

Values in brackets are informative

Analysis	Al	*	C	*	Co**	*	Cr	*	Cu	*	Fe	*	H**	*	Mn	*
1	0.4981	1	0.0431	3	0.0060	1	18.93	6	0.002	1	17.03	1	0.00090	4	0.008	2
2	0.519	2	0.04316	3	0.0102	1	19.0636	1	0.0094	1	17.12	1	0.00052	4	0.010	1
3	0.5257	1	0.0441	3	0.0107	1	19.073	1	0.01005	1	17.1427	1			0.0103	1
4	0.5268	1	0.0458	3	0.01356	1	19.10	1	0.0136	1	17.1511	1			0.0107	1
5	0.536	1	0.047	3			19.17	1	0.015	1	17.27	6			0.01429	1
6	0.57	1	0.047	3			19.21	1			17.54	1			0.0337	1
7			0.0431	3												
Average	0.53		0.045		0.012		19.09		0.010		17.17		0.0007		0.011	
Standard deviation	0.013		0.013		-		0.084		0.0049		0.10		-		0.0023	
u characterization	0.0067		0.0067		-		0.043		0.0028		0.052		-		0.0012	
u homogeneity	0.0099		0.00057		-		0.16		0.00052		0.28		-		0.00027	
Certified value	0.53		0.045		-		19.09		0.010		17.17		-		0.011	
Expanded uncertainty	0.04		0.003		-		0.63		0.006		0.83		-		0.002	

Analysis	Mo	*	N	*	Nb	*	Ni	*	O	*	S	*	Si	*	Ti	*
1	3.06151	1	0.0027	4	5.0663	1	53.37	1	0.0130	4	0.0018	3	0.0356	1	1.006	1
2	3.085	1	0.0140	4	5.102	1	53.51	7	0.0131	4	0.00223	3	0.0425	1	1.0168	1
3	3.0915	1	0.0147	4	5.109	1	53.8643	5	0.0148	4	0.0024	3	0.0504	1	1.03926	1
4	3.121	1	0.0170	4	5.1278	1	53.9421	1	0.0208	4	0.0026	3	0.05084	1	1.047	1
5	3.20	1	0.0205	4	5.409	1	54.12	5	0.022	4	0.0027	3	0.060	1	1.14	1
6	3.31	2					54.28	1			0.0036	3				
Average	3.12		0.0150		5.11		53.85		0.0157		0.0025		0.048		1.04	
Standard deviation	0.050		0.0038		0.031		0.35		0.0029		0.0004		0.0092		0.032	
u characterization	0.025		0.0021		0.017		0.18		0.0016		0.00019		0.0052		0.018	
u homogeneity	0.052		0.00104		0.12		0.25		0.00082		0.00016		0.0026		0.026	
Certified value	3.12		0.0150		5.11		53.85		0.0157		0.0025		0.048		1.04	
Expanded uncertainty	0.16		0.0049		0.36		0.86		0.0075		0.0005		0.011		0.07	

Analysis	V**	*	W**	*
1	0.00241	1	0.0001	1
2	0.0034	1	0.001	1
3	0.0048	1	0.00584	1
4	0.0106	1	0.0101	1
5	0.0113	1	0.020	1
Average	0.006		0.007	
Standard deviation	-		-	
u characterization	-		-	
u homogeneity	-		-	
Certified value	-		-	
Expanded uncertainty	-		-	

* - analytical method used, ** - informative value

All values are based on recommendations of the ISO 33405:2024 standard:

- average** is calculated according to Algorithm A (ISO 33405:2024 clause A.2.3.4),
- standard deviation** is calculated according to Algorithm A (ISO 33405:2024 A.2.3.4),
- certified value** is the average value rounded to one or two significant digits of expanded uncertainty,
- expanded uncertainty** for each certified element was calculated using a coverage factor of $k=2$ corresponding to an approximate 95% confidence level $U_{CRM} = k \cdot u_{CRM}$. The combined standard uncertainty (u_{CRM}) associated with each certified value was determined as shown:

$$u_{CRM} = \sqrt{u_{char}^2 + u_{hom}^2 + u_{sts}^2 + u_{lts}^2}$$

where:

- u_{char} uncertainty of characterisation was derived from the results of an interlaboratory comparison performed under repeatability conditions by network of competent laboratories (ISO 33405:2024 clause 9.5) and calculated according to clause B.5.2,
- u_{hom} between-unit uncertainty was calculated based on analysis of variance (ANOVA) using a stratified sampling design. Subsamples were extracted from multiple depth levels of randomly selected units, and standard uncertainties were estimated from between-unit and within-unit variance components, in agreement with ISO 33405:2024 clause 7.11,
- u_{sts} short time stability uncertainty was evaluated under conditions typically encountered during transportation (ISO 33405:2024 clause 8.3.4.1). The study simulated the maximum expected thermal and mechanical stress associated with sample shipment and handling. u_{sts} was considered negligible,
- u_{lts} long-term stability uncertainty was estimated using a linear regression model, consistent with the ISO 33405:2024 clause 8.7.3. This approach followed a predictive methodology under the assumption of a linear trend in the stability data. For each analyte, a linear regression was fitted to the results obtained during the long-term (52 months) stability study. In all cases the regression slope was not statistically significant (i.e. the absolute value of the Student's t-statistic for the slope did not exceed the critical value at the 95% confidence

level). The absence of a meaningful trend allowed for the extrapolation of shelf-life based on the model's prediction interval.

Certification Process: Both preparation of this Reference Material and certification process were prepared according to requirements PN-EN 17034 and ISO 33405:2024.

Chemical Analysis: Chemical analyses were carried out on metallic powder samples. Single values in the above table are the means obtained by individual laboratories. The following methods were used for analysis:

- 1 – inductive coupled plasma atomic emission spectrometry,
- 2 – flame atomic emission spectrometry,
- 3 – combustion,
- 4 – inert gas fusion,
- 5 – gravimetry,
- 6 – titrimetry,
- 7 – photometry.

Participating Laboratories:

- Bundesanstalt für Materialforschung und -prüfung (BAM) (Germany), DAKKs accreditation D-PL-11075-14-00, ISO 17025,
- Dunafer Labor Nonprofit Kft., Dunaújváros (Hungary), NAH accreditation NAH-1-1798/2021, ISO 17025
- Lithea, Ltd. (Czech Republic),
- OnderzoeksCentrum voor de Aanwending van Staal, Zelzate (Belgium),
- Sieć Badawcza Łukasiewicz - Górnośląski Instytut Technologiczny (Poland), PCA accreditation AB 554, ISO 17025,
- Sieć Badawcza Łukasiewicz - Instytut Metali Nieżelaznych (Poland), PCA accreditation AB 274, ISO 17025,
- Laboratory Testing Inc. (USA), NADCAP accreditation 3296228778, ISO 17025,
- Vítkovice Testing Center (Czech Republic), Testing Laboratory Nr 1036, CAI accreditation, ISO 17025.

Homogeneity: The homogeneity of this Reference Material was evaluated in accordance with guidelines of ISO 33405:2024. Optical emission spectrometry with plasma excitation method was used.

Traceability: This Reference Material was found traceable to the following CRMs:

B2400, B2420, B2424, B2752, BCS 463/1, BCS 466/2, BS 199B, BS 200A, BS 718C, BS 718D, BS H1C, BS H2C, BS H2E, BSH3C, Eltra 92400-3040, EN-ZRM 098-1, Euro 042-1, Euro 187-1, IARM 56B, IARM 65G, IARM 65H, Leco 501-505, LGC 718, MBH C24X, MBH C28X 62520, MBH C28X 71820, MBH C28X 71860, NBS 168, pure chemicals

Production of powder: This material was manufactured by Electro Optical Systems Finland Oy (Finland) using gas atomisation, lot number K041901, manufactured on 01 March 2019.

Available form: Powder.

Intended use: This Reference Material is intended for use in inductively coupled plasma atomic emission spectrometry, flame atomic emission spectrometry, combustion with infrared detection, high-temperature extraction with thermal conductivity detection, gravimetry, titrimetry, and photometry.

Note: The minimum sample portion recommended for analysis is:

- 0,1 g for O, N,
- 0,5 g for other elements - corresponding to the test portion used in the homogeneity study.

Validity of certification: The certification of IMZ IN 718 PWD is valid indefinitely within the uncertainty specified provided this Reference Material is stored in dry place and in environment free from chemical or other aggressive vapours. Periodic recertification is not required. The certification is nullified if this Reference Material is damaged, contaminated or otherwise modified. Based on a stability study using linear model prediction, the **shelf-time** of this reference material has been established as **75 months** from the date of certificate issue.

Safety: This material is a fine metallic powder. Avoid inhalation, ingestion, and contact with skin or eyes. Use only in well-ventilated areas or under local exhaust ventilation. Wear appropriate personal protective equipment, including safety glasses, gloves, and a dust mask or respirator conforming to relevant standards. Keep away from sources of ignition and strong oxidising agents. Handle in accordance with good laboratory practice.

Storage: This Reference Material should be stored in dry place and in environment free from chemical or other aggressive vapours

Additional information: The values listed below are taken from the powder manufacturer's Inspection Certificate for the source material from which the certified reference material was prepared. Values are informative.

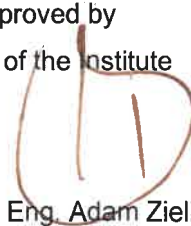
Particle Size Distribution Analysis

Test method	Size characteristics	Result
Laser diffraction	d10 [μm]	20.60
	d50 [μm]	33.52
	d90 [μm]	52.03

Laser diffraction analysis according to ISO 13320

Inquiries regarding this Reference Material should be directed to rm@git.lukasiewicz.gov.pl

Approved by
Director of the Institute



Prof. Dr. Hab. Eng. Adam Zieliński

Certificate issue date: 3 August 2026