



# Certificate of Analysis

## Certified Reference Material

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### HVAN-1

#### High Purity Vanadium Certified Reference Material for Vanadium Mass Fraction and Elemental Impurities

HVAN-1 is a high purity vanadium Certified Reference Material (CRM). A unit of HVAN-1 consists of approximately 1 g of high purity vanadium. This material is intended as a primary standard for the determination of mass fraction of vanadium.

Certified values for the mass fractions of vanadium and elemental impurities have been established for HVAN-1. These values are listed in the Tables 1 and 2. Certified values are based on measurements carried out at the National Research Council of Canada (NRC).

**Table 1: Certified quantity value and expanded uncertainty ( $k = 2$ ) of mass fraction of vanadium in for HVAN-1**

Quantity	Value	Expanded uncertainty
Mass fraction of vanadium, $w(V)/(kg/kg)$	0.999 641	0.000 109

Table 1 shows the derived quantity that characterizes the property of vanadium in HVAN-1, and this quantity was calculated using the following mathematical expression:

$$w(V) = 1 - \sum_E w(E)$$

Here, E refers to the elements listed in Table 2. Other elements such as hydrogen, noble gases or any other elements not listed in Table 2 were considered in the purity estimate with mass fraction assigned to zero and no associated uncertainty.

Table 2 shows elemental impurities of vanadium. For the purposes of obtaining the mass fraction (purity) estimate of vanadium, all elemental impurities below detection limit were interpreted as half the detection limit (for example '<2  $\mu\text{g}/\text{kg}$ ' for lithium is interpreted as 1  $\mu\text{g}/\text{kg}$ ). A robust estimator (median) was used to summarize the observed values from 15 units reported in Table 2.

Period of validity: until March 2036

Storage conditions: room temperature

**Table 2: Certified quantity values and expanded uncertainties ( $k = 2$ ) of mass fractions of elemental impurities in HVAN-1 ( $\mu\text{g}/\text{kg}$ )**

Impurity element, E	Mass fraction, $w(E)$	Expanded uncertainty	Impurity element, E	Mass fraction, $w(E)$	Expanded uncertainty
Li	<2	2	Pd	<10	5
Be	<1	1	Ag	<12	6
B	410	210	Cd	<73	37
C	60 000	42 000	In	<6	3
N	57 000	52 000	Sn	<19	9
O	104 000	83 000	Sb	<6	3
F	<9	24	Te	<22	11
Na	1	10	I	<1	4
Mg	<3	1	Cs	<2	3
Al	27 000	8000	Ba	<8	12
Si	82 000	16 000	La	<0.5	0.3
P	2300	1600	Ce	<0.5	0.3
S	1200	700	Pr	<1	1
Cl	1	8	Nd	<2	1
K	<22	24	Sm	<2	5
Ca	<28	330	Eu	<1	3
Sc	9	9	Gd	<2	5
Ti	1700	900	Tb	<1	1
V	Matrix	Matrix	Dy	<2	5
Cr	<180	240	Ho	<1	1
Mn	<2	1	Er	<2	4
Fe	5800	1700	Tm	<1	1
Co	17	5	Yb	<2	4
Ni	3100	900	Lu	<1	1
Cu	25	12	Hf	<4	3
Zn	100	140	Ta	<7600	7600
Ga	52	21	W	160	130
Ge	<40	38	Re	36	94
As	12	4	Os	<18	25
Se	<44	22	Ir	<6	8
Br	<13	34	Pt	<8	4
Rb	<4	6	Au	<1700	800
Sr	<11	7	Hg	<59	41
Y	<3700	5200	Tl	<16	9
Zr	2200	1100	Pb	<6	3
Nb	<280	170	Bi	<6	3
Mo	5700	1100	Th	<3	4
Ru	<10	13	U	<3	4
Rh	<4	5			

## **Intended use**

This CRM is intended to be dissolved, in whole, to make a primary standard for the determination of the mass fraction of vanadium. If the procedure for preparing the primary standard solution involves weighing the CRM, an appropriate cleaning should be performed to remove surface contamination.

Mass fractions of the impurities reported on this certificate are not intended for calibration purposes. This data is presented to allow users to compute/derive purity and assess the impact of concomitant impurities when a mixed element standard solution is prepared. However, if the impurity values are used in a measurement (XRF, laser ablation etc.) appropriate care should be taken to remove any surface contamination.

## **Preparation of material**

This CRM was prepared from a 2 mm diameter high-purity vanadium metal wire. It was cut into approximately 26.5 mm long pieces using a wire electrical discharge technique at the NRC and bottled in 4 mL glass vials filled with argon. Each unit contains approximately 1 g of vanadium.

## **Characterization of material**

The certified values for HVAN-1 (Tables 1 and 2) are based on results obtained at the NRC using Glow Discharge Mass Spectrometry (GD-MS).

## **Metrological traceability**

Results presented in this certificate are traceable to the International System of Units (SI) through a network of CRMs [1, 2]. As such, HVAN-1 serves as a suitable reference material for laboratory quality assurance programs, as outlined in ISO/IEC 17025.

## **Homogeneity**

The material was tested for homogeneity at the NRC by analyzing 15 CRM units. See [10.4224/crm.2026.hvan-1](https://www.nrc.gov/tech/standards/crm/10.4224/crm.2026.hvan-1) for data on each of these units.

## **Stability**

Potential instabilities due to long-term storage and transport were considered, and such effects deemed to be negligible on the purity of the material. The material is deemed stable with respect to the certified values for ten years.

## **Uncertainty**

The expanded uncertainty ( $U$ ) for all values is equal to  $U = ku_c$ , where  $u_c$  is the combined standard uncertainty calculated according to the Joint Committee for Guides in Metrology (JCGM) [3] and  $k$  is the coverage factor. A coverage factor of  $k = 2$  was applied which corresponds to a level of confidence of approximately 95 %.

All reasonable sources of uncertainty related to the certified values in Tables 1 and 2 were considered. Included in the combined uncertainty estimate are uncertainties related to the batch characterization, primary standards, calibration model, and measurement repeatability.

## **Storage**

The material shall be stored at room temperature.

## **Instructions for handling and use**

The vials should only be opened immediately prior to use in a clean area, taking precautions against contamination.

## Health and safety information

Only qualified personnel should handle the material and appropriate disposal methods should be used. A Safety Data Sheet (SDS) is available at [10.4224/crm.2026.hvan-1](https://www.nrc.ca/10.4224/crm.2026.hvan-1). For laboratory use only; not for human consumption, therapeutic, drug, household, or any other uses.

## Period of validity

NRC CRM HVAN-1 is valid until March 2036, provided the storage and instructions for handling and use specified in this certificate are followed.

## Quality management system

The NRC is Canada's national metrology institute (NMI) and is a signatory of the International Committee for Weights and Measures Mutual Recognition Arrangement (CIPM MRA). The CIPM MRA was developed in a response to a growing need for an open, transparent, and comprehensive scheme to give users reliable quantitative information on the comparability of national metrology services and to provide the technical basis for wider agreements negotiated for international trade, commerce, and regulatory affairs. Our Quality Management System for measurement services and certified reference materials conforms to the requirements of ISO/IEC 17025 and ISO 17034.

The Calibration and Measurement Capabilities (CMCs) supporting the result in Table 1 is listed in the International Bureau of Weights and Measures (BIPM) Key Comparison Database (<https://www.bipm.org/kcdb/>) which recognizes the validity of the measurements performed by NMIs participating in the CIPM MRA. The NRC has the following CMC relevant for this material: SIM-QM-CA-0000011Z-1 (purity determination of high purity vanadium).

## Description of terms

Certified values are those for which the NRC has the highest confidence and that all known and suspected sources of bias have been considered by the NRC and are reflected in the stated expanded uncertainties.

## Supplemental information

The accompanying data sheets (available from [10.4224/crm.2026.hvan-1](https://www.nrc.ca/10.4224/crm.2026.hvan-1)) provide elemental impurity results from the analyzed CRM units, the mass and chemical amount of vanadium in any given unit along with the mass of individual units and their expanded uncertainties. The serial number corresponding to each unit is located on the HVAN-1 vial.

## References

1. Meija J, Methven B, Sturgeon RE. Uncertainty of relative sensitivity factors in glow discharge mass spectrometry. *Metrologia* 2017; 54: 796-804. [doi.org/10.1088/1681-7575/aa83d6](https://doi.org/10.1088/1681-7575/aa83d6)
2. Sturgeon RE, Methven B, Willie SN, Grinberg P. Assignment of purity to primary metal calibrants using a pin-cell VG 9000 glow discharge mass spectrometer - a primary method with direct traceability to the SI international system of units? *Metrologia* 2014; 51: 410-422. [doi.org/10.1088/0026-1394/51/5/410](https://doi.org/10.1088/0026-1394/51/5/410)
3. JCGM 100:2008. Evaluation of measurement data – Guide to the expression of uncertainty in measurement. Joint Committee for Guides in Metrology (JCGM); 2008. [doi.org/10.59161/JCGM100-2008E](https://doi.org/10.59161/JCGM100-2008E)

## Authorship

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This certificate is only valid if the corresponding material was obtained directly from the NRC or an authorized reseller. Users should ensure that the certificate they have is current. For updates, please refer to [10.4224/crm.2026.hvan-1](https://www.nrc.ca/10.4224/crm.2026.hvan-1).

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