55 Gas-Composition Presets

Preset inputs, calculation basis and derived ideal-gas outputs

This catalogue records 55 application presets from the supplied September 2026 catalogue. It retains every listed raw gas amount, temperature, pressure and displayed derived result. Inputs are normalized as relative mole amounts for calculation.

Scope. These are physically informed and illustrative project scenarios. Numerical agreement with the model does not establish measured planetary conditions or validate the model across every temperature, pressure or phase.

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Dataset v1.1.0 • Preset snapshot: September 2026 • Document edition: October 2026

Calculation method

Raw gas amounts r_i are retained exactly as supplied. Calculations use normalized mole fractions x_i. All derived outputs use the application constants on page 3; these are model calculations.

Step	Definition and units	Equation
Normalize	Relative mole amounts; $\Sigma x_i = 1$.	$x_i = r_i / \Sigma_j r_j$
Mixture mass	Mean molar mass M in kg/mol.	$M = \Sigma_i x_i M_i$
Heat capacity	Molar C_p and C_v in J/(mol·K).	$C_p = \Sigma_i x_i C_{p,i}$; $C_v = C_p$ - R
Heat ratio	Dimensionless ratio of heat capacities.	$\gamma = C_p / C_v$
Speed of sound	Ideal-gas sound speed c in m/s.	$c = \sqrt{(\gamma RT / M)}$
Density	Ideal-gas density ρ in kg/m³.	$\rho = PM / (RT)$
Impedance	Characteristic acoustic impedance Z in Rayl.	$Z = \rho c$
Brightness	Bounded dimensionless audio-control mapping.	B = clamp(√[0.02897 / max(M, 0.000001)], 0.70, 1.30)

Unit conversions: T(K) = T(°C) + 273.15; P(Pa) = 1000 × P(kPa). The sound-speed and density equations use kelvin, pascals and kg/mol. The output tables display M in g/mol, converted from kg/mol.

Calculation conditions: $\Sigma r_i > 0$, T > 0 K, M > 0 and $C_v > 0$. All supplied rows meet these conditions. The brightness guard is 0.000001 kg/mol. NASA uses the specific gas constant R/M in its equivalent sound-speed expression [4].

Model constants and catalogue IDs

The following values match the fixed application table in Technical Guide v1.2, Section 2.2 [1]. Heat capacities vary with temperature. A common reference temperature and an individual source for each adopted C_p value have not been established; this is a model-constant table.

Gas	M_i (kg/mol)	$C_{p,i}$ [J/(mol·K)]	Gas	M_i (kg/mol)	$C_{p,i}$ [J/(mol·K)]
CO_2	0.044010	37.14	H_2	0.002016	28.84
N_2	0.028014	29.12	He	0.004003	20.79
CH_4	0.016043	35.69	H_2O vapour	0.018015	33.58
O_2	0.031998	29.38	NH_3	0.017031	35.70
Ar	0.039948	20.79	SO_2	0.064063	39.87

Gas constant: R = 8.314463 J/(mol·K) is the rounded implementation value used throughout these calculations. CODATA gives R = 8.314462618... J/(mol·K), exact in the SI [2]. The adopted molar masses are rounded values.

Thermochemical reference: NIST Chemistry WebBook [3] supplies molecular and thermochemical reference data. Its citation does not establish that every fixed heat-capacity value above was extracted at one reference temperature.

Catalogue IDs and Sequence Steps. P001–P055 identify rows in this document. A correspondence with WorldIndex 0–54 has not been independently verified against a current Blueprint export. For Sequence Steps or Auto Play Sequence Steps, confirm the preset name and WorldIndex in the application before entering the index. Catalogue IDs and SoundIndex values refer to different lists.

Preset inputs | P001 to P013

Gas fields are raw relative amounts in percentage-style units; totals need not equal 100. Only non-zero gases are shown. “Named preset” means no model qualifier was supplied; it does not imply observational verification.

ID	Preset	Raw gas amounts (%)	T (°C)	P (kPa)	Raw total (%)	Descriptor
P001	Earth Reference	CO_2 0.04; N_2 78.08; CH_4 0.0002; O_2 20.95; Ar 0.93; H_2 0.00005; He 0.0005	20	101.325	100.001	Earth reference
P002	Mars	CO_2 95.32; N_2 2.7; O_2 0.13; Ar 1.6; H_2O 0.03	-63	0.636	99.78	Named preset
P003	Venus	CO_2 96.5; N_2 3.48; Ar 0.007; SO_2 0.015	464	9200	100.002	Named preset
P004	Mercury (Exosphere Model)	N_2 29; O_2 42; Ar 1; H_2 22; He 6	167	0.0000001	100	Exosphere Model
P005	Jupiter	CH_4 0.3; H_2 89.46; He 10.2; H_2O 0.01; NH_3 0.03	-110	100	100	Named preset
P006	Saturn	CH_4 0.45; H_2 96.28; He 3.25; H_2O 0.01; NH_3 0.01	-140	100	100	Named preset
P007	Uranus	CH_4 2.3; H_2 82.5; He 15.2	-195	100	100	Named preset
P008	Neptune	CH_4 1.5; H_2 79.5; He 19	-200	100	100	Named preset
P009	Moon (Exosphere Model)	Ar 40; H_2 20; He 40	-20	0	100	Exosphere Model
P010	Io	O_2 5; Ar 5; SO_2 90	-130	0.0001	100	Named preset
P011	Europa	O_2 99; H_2O 1	-160	0.0000001	100	Named preset
P012	Ganymede	O_2 95; H_2O 5	-160	0.000001	100	Named preset
P013	Callisto	CO_2 90; O_2 10	-140	0.000001	100	Named preset

Preset inputs | P014 to P027

Gas fields are raw relative amounts in percentage-style units; totals need not equal 100. Only non-zero gases are shown. “Named preset” means no model qualifier was supplied; it does not imply observational verification.

ID	Preset	Raw gas amounts (%)	T (°C)	P (kPa)	Raw total (%)	Descriptor
P014	Titan	N_2 98.3; CH_4 1.6; H_2 0.1	-179	146.7	100	Named preset
P015	Enceladus (Plume Model)	CO_2 5; CH_4 1; H_2 4; H_2O 90	-198	0.001	100	Plume Model
P016	Dione (Exosphere Model)	CO_2 30; O_2 70	-186	0.0000001	100	Exosphere Model
P017	Rhea (Exosphere Model)	CO_2 30; O_2 70	-174	0.0000001	100	Exosphere Model
P018	Iapetus (Model)	CO_2 60; O_2 20; H_2O 20	-143	0.0000001	100	Model
P019	Triton	N_2 99.4; CH_4 0.5; Ar 0.1	-235	0.0014	100	Named preset
P020	Pluto	N_2 98; CH_4 1.5; Ar 0.5	-229	0.001	100	Named preset
P021	Ceres (Vapour Model)	CO_2 20; H_2O 80	-105	0.00001	100	Vapour Model
P022	Eris (Seasonal Model)	N_2 98; CH_4 2	-231	0.000001	100	Seasonal Model
P023	Makemake (Seasonal Model)	N_2 95; CH_4 5	-239	0.000001	100	Seasonal Model
P024	Haumea (Vapour Model)	H_2O 100	-241	0.000001	100	Vapour Model
P025	WASP-121 b (Model)	CO_2 0.05; CH_4 0.01; H_2 85; He 14.7; H_2O 0.24	2450	100	100	Model
P026	WASP-39 b (Model)	CO_2 0.3; H_2 85; He 14.48; H_2O 0.2; SO_2 0.02	900	100	100	Model
P027	HD 189733 b (Model)	CH_4 0.1; H_2 85; He 14.6; H_2O 0.3	1200	100	100	Model

Preset inputs | P028 to P038

Gas fields are raw relative amounts in percentage-style units; totals need not equal 100. Only non-zero gases are shown. “Named preset” means no model qualifier was supplied; it does not imply observational verification.

ID	Preset	Raw gas amounts (%)	T (°C)	P (kPa)	Raw total (%)	Descriptor
P028	HD 209458 b (Model)	H_2 85; He 14.75; H_2O 0.25	1450	100	100	Model
P029	55 Cancri e (Rock-Vapour Model)	CO_2 40; N_2 30; O_2 10; Ar 10; SO_2 10	2400	100	100	Rock-Vapour Model
P030	GJ 486 b (Rock-Vapour Model)	CO_2 45; N_2 25; O_2 10; Ar 10; SO_2 10	430	10	100	Rock-Vapour Model
P031	LP 791-18 d (Volcanic Model)	CO_2 70; N_2 15; Ar 5; H_2O 5; SO_2 5	100	100	100	Volcanic Model
P032	K2-18 b (H2-Rich Model)	CO_2 0.8; CH_4 1; H_2 85; He 13; H_2O 0.2	27	500	100	H2-Rich Model
P033	GJ 1214 b (Steam-Haze Model)	CO_2 2; CH_4 3; H_2 70; He 15; H_2O 10	230	500	100	Steam-Haze Model
P034	TOI-270 d (H2-Rich Model)	CO_2 1; CH_4 1; H_2 82; He 14; H_2O 2	60	500	100	H2-Rich Model
P035	LHS 1140 b (Ocean Model)	CO_2 15; N_2 80; H_2O 5	0	200	100	Ocean Model
P036	TRAPPIST-1 e (Temperate Model)	CO_2 1; N_2 78; O_2 20; Ar 0.5; H_2O 0.5	10	100	100	Temperate Model
P037	TRAPPIST-1 f (Cold CO2 Model)	CO_2 20; N_2 75; Ar 2; H_2O 3	-40	200	100	Cold CO2 Model
P038	TRAPPIST-1 g (Dense CO2 Model)	CO_2 40; N_2 55; Ar 2; H_2O 3	-60	300	100	Dense CO2 Model

Preset inputs | P039 to P048

Gas fields are raw relative amounts in percentage-style units; totals need not equal 100. Only non-zero gases are shown. “Named preset” means no model qualifier was supplied; it does not imply observational verification.

ID	Preset	Raw gas amounts (%)	T (°C)	P (kPa)	Raw total (%)	Descriptor
P039	Proxima Centauri b (Temperate Model)	CO_2 1; N_2 78; O_2 20; H_2O 1	5	100	100	Temperate Model
P040	TOI-700 d (Temperate Model)	CO_2 10; N_2 85; H_2O 5	15	120	100	Temperate Model
P041	Kepler-452 b (Earthlike Model)	CO_2 0.1; N_2 77.9; O_2 20.5; Ar 0.5; H_2O 1	25	110	100	Earthlike Model
P042	Kepler-186 f (Temperate Model)	CO_2 5; N_2 90; Ar 1; H_2O 4	-10	120	100	Temperate Model
P043	Kepler-62 f (Ocean Model)	CO_2 10; N_2 80; H_2O 10	0	180	100	Ocean Model
P044	Pure CO2 Reference	CO_2 100	20	101.325	100	Pure-gas reference
P045	Pure N2 Reference	N_2 100	20	101.325	100	Pure-gas reference
P046	Pure CH4 Reference	CH_4 100	20	101.325	100	Pure-gas reference
P047	Europa - Surface Exosphere	CO_2 0.5; O_2 95; H_2 3; H_2O 1.5	-170	0.0001	100	Surface Exosphere model
P048	Europa - Ice Shell	CO_2 45; O_2 25; H_2 5; H_2O 10; SO_2 15	-180	0.001	100	Ice Shell model

Preset inputs | P049 to P055

Gas fields are raw relative amounts in percentage-style units; totals need not equal 100. Only non-zero gases are shown. “Named preset” means no model qualifier was supplied; it does not imply observational verification.

ID	Preset	Raw gas amounts (%)	T (°C)	P (kPa)	Raw total (%)	Descriptor
P049	Europa - Subsurface Ocean	CO_2 15; CH_4 2; H_2 10; H_2O 60; NH_3 8; SO_2 5	-2	250	100	Subsurface Ocean model
P050	Early Earth - Hadean Eon	CO_2 80; N_2 10; CH_4 1; H_2 1; H_2O 5; SO_2 3	230	600	100	Hadean Eon model
P051	Early Earth - Archean Eon	CO_2 20; N_2 70; CH_4 7; He 2; H_2O 1	25	70	100	Archean Eon model
P052	Early Earth - Great Oxidation Event	CO_2 15; N_2 78; CH_4 3; O_2 2; H_2O 2	-10	100	100	Great Oxidation Event model
P053	Future Earth - Moist Greenhouse	CO_2 3; N_2 65; CH_4 0.01; O_2 5; Ar 0.7; H_2 0.3; H_2O 25; SO_2 0.05	65	130	99.06	Moist Greenhouse model
P054	Future Earth - Dense CO2 Greenhouse	CO_2 40; N_2 35; O_2 2; Ar 1; H_2 2; H_2O 20	120	500	100	Dense CO2 Greenhouse model
P055	Future Earth - Steam Atmosphere	CO_2 20; N_2 8; O_2 0.5; Ar 0.4; H_2 1; H_2O 70; SO_2 0.1	200	1000	100	Steam Atmosphere model

Derived outputs | P001 to P015

Calculated from normalized inputs using the fixed constants on page 3. M is displayed in g/mol; γ and B are dimensionless. Values retain their original precision. Flags are defined in the interpretation section.

ID	Preset	M (g/mol)	C_p J/(mol·K)	C_v J/(mol·K)	γ (-)	c (m/s)	ρ (kg/m³)	Z (Rayl)	B (-)	Flag
P001	Earth Reference	28.9659	29.10	20.79	1.400	343.2	1.2041	413.3	1.000	-
P002	Mars	43.4886	36.65	28.34	1.293	228.0	0.01583	3.6086	0.816	NORM
P003	Venus	43.4561	36.86	28.55	1.291	426.8	65.2301	27837.25	0.816	-
P004	Mercury (Exosphere Model)	22.6464	28.58	20.27	1.410	477.4	6.19e-10	2.95e-07	1.131	LOW-P
P005	Jupiter	2.2669	28.04	19.73	1.421	922.3	0.1671	154.12	1.300	-
P006	Saturn	2.1468	28.61	20.30	1.410	852.6	0.1939	165.34	1.300	-
P007	Uranus	2.6406	27.77	19.46	1.427	592.6	0.4064	240.84	1.300	-
P008	Neptune	2.6039	27.41	19.10	1.435	579.0	0.4281	247.9	1.300	-
P009	Moon (Exosphere Model)	17.9836	22.40	14.09	1.590	431.4	0	0	1.269	ZERO-P
P010	Io	61.2540	38.39	30.08	1.276	157.5	5.15e-06	8.11e-04	0.700	LOW-P
P011	Europa	31.8582	29.42	21.11	1.394	202.9	3.39e-09	6.87e-07	0.954	LOW-P
P012	Ganymede	31.2988	29.59	21.28	1.391	204.5	3.33e-08	6.80e-06	0.962	LOW-P
P013	Callisto	42.8088	36.36	28.05	1.296	183.1	3.87e-08	7.08e-06	0.823	LOW-P
P014	Titan	27.7965	29.22	20.91	1.398	198.4	5.2091	1033.46	1.021	-
P015	Enceladus (Plume Model)	18.6551	33.59	25.28	1.329	211.0	2.99e-05	0.0063	1.246	LOW-P

Derived outputs | P016 to P030

Calculated from normalized inputs using the fixed constants on page 3. M is displayed in g/mol; γ and B are dimensionless. Values retain their original precision. Flags are defined in the interpretation section.

ID	Preset	M (g/mol)	C_p J/(mol·K)	C_γ J/(mol·K)	γ (-)	c (m/s)	ρ (kg/m³)	Z (Rayl)	B (-)	Flag
P016	Dione (Exosphere Model)	35.6016	31.71	23.39	1.355	166.1	4.91e-09	8.16e-07	0.902	LOW-P
P017	Rhea (Exosphere Model)	35.6016	31.71	23.39	1.355	177.2	4.32e-09	7.65e-07	0.902	LOW-P
P018	Iapetus (Model)	36.4086	34.88	26.56	1.313	197.5	3.36e-09	6.65e-07	0.892	LOW-P
P019	Triton	27.9661	29.14	20.83	1.399	126.0	1.23e-04	0.0155	1.018	LOW-P
P020	Pluto	27.8941	29.18	20.86	1.399	135.7	7.60e-05	0.0103	1.019	LOW-P
P021	Ceres (Vapour Model)	23.2140	34.29	25.98	1.320	282.0	1.66e-07	4.68e-05	1.117	LOW-P
P022	Eris (Seasonal Model)	27.7746	29.25	20.94	1.397	132.8	7.93e-08	1.05e-05	1.021	LOW-P
P023	Makemake (Seasonal Model)	27.4154	29.45	21.13	1.393	120.1	9.66e-08	1.16e-05	1.028	LOW-P
P024	Haumea (Vapour Model)	18.0150	33.58	25.27	1.329	140.4	6.74e-08	9.46e-06	1.268	LOW-P
P025	WASP-121 b (Model)	2.3689	27.67	19.36	1.430	3696.4	0.010463	38.67	1.300	HIGH-T
P026	WASP-39 b (Model)	2.4741	27.71	19.40	1.429	2373.3	0.025365	60.2	1.300	-
P027	HD 189733 b (Model)	2.3681	27.69	19.37	1.429	2718.9	0.019334	52.57	1.300	HIGH-T
P028	HD 209458 b (Model)	2.3491	27.66	19.35	1.430	2952.9	0.016396	48.42	1.300	HIGH-T
P029	55 Cancri e (Rock-Vapour Model)	39.6091	32.60	24.28	1.342	867.9	0.1782	154.67	0.855	HIGH-T
P030	GJ 486 b (Rock-Vapour Model)	40.4089	33.00	24.68	1.337	439.8	0.069119	30.4	0.847	-

Derived outputs | P031 to P044

Calculated from normalized inputs using the fixed constants on page 3. M is displayed in g/mol; γ and B are dimensionless. Values retain their original precision. Flags are defined in the interpretation section.

ID	Preset	M (g/mol)	C_p J/(mol·K)	C_γ J/(mol·K)	γ (-)	c (m/s)	ρ (kg/m³)	Z (Rayl)	B (-)	Flag
P031	LP 791-18 d (Volcanic Model)	41.1104	35.08	26.76	1.311	314.5	1.3251	416.74	0.839	-
P032	K2-18 b (H2-Rich Model)	2.7825	27.94	19.62	1.424	1130.0	0.5575	629.96	1.300	-
P033	GJ 1214 b (Steam-Haze Model)	5.1746	28.48	20.16	1.412	1068.6	0.6185	660.87	1.300	-
P034	TOI-270 d (H2-Rich Model)	3.1744	27.96	19.64	1.423	1114.4	0.573	638.56	1.300	-
P035	LHS 1140 b (Ocean Model)	29.9135	30.55	22.23	1.374	323.0	2.6343	850.82	0.984	-
P036	TRAPPIST-1 e (Temperate Model)	28.9804	29.23	20.92	1.397	336.9	1.231	414.76	1.000	-
P037	TRAPPIST-1 f (Cold CO2 Model)	31.1519	30.69	22.38	1.372	292.1	3.214	938.96	0.964	-
P038	TRAPPIST-1 g (Dense CO2 Model)	34.3511	32.30	23.98	1.347	263.6	5.8149	1532.74	0.918	-
P039	Proxima Centauri b (Temperate Model)	28.8708	29.30	20.98	1.396	334.4	1.2484	417.5	1.002	-
P040	TOI-700 d (Temperate Model)	29.1136	30.14	21.83	1.381	337.1	1.4582	491.56	0.998	-
P041	Kepler-452 b (Earthlike Model)	28.8064	29.18	20.87	1.398	346.9	1.2782	443.42	1.003	-
P042	Kepler-186 f (Temperate Model)	28.5332	29.62	21.30	1.390	326.5	1.5649	510.97	1.008	-
P043	Kepler-62 f (Ocean Model)	28.6137	30.37	22.05	1.377	330.6	2.2678	749.74	1.006	-
P044	Pure CO2 Reference	44.0100	37.14	28.83	1.288	267.1	1.8295	488.72	0.811	-

Derived outputs | P045 to P055

Calculated from normalized inputs using the fixed constants on page 3. M is displayed in g/mol; γ and B are dimensionless. Values retain their original precision. Flags are defined in the interpretation section.

ID	Preset	M (g/mol)	C_p J/(mol·K)	C_γ J/(mol·K)	γ (-)	c (m/s)	ρ (kg/m³)	Z (Rayl)	B (-)	Flag
P045	Pure N2 Reference	28.0140	29.12	20.81	1.400	349.0	1.1646	406.39	1.017	-
P046	Pure CH4 Reference	16.0430	35.69	27.38	1.304	445.1	0.6669	296.82	1.300	-
P047	Europa - Surface Exosphere	30.9489	29.47	21.15	1.393	196.5	3.61e-06	7.09e-04	0.968	LOW-P
P048	Europa - Ice Shell	39.3157	34.84	26.52	1.313	160.9	5.08e-05	0.0082	0.858	LOW-P
P049	Europa - Subsurface Ocean	22.4986	34.17	25.85	1.322	363.9	2.4949	907.92	1.135	-
P050	Early Earth - Hadean Eon	41.0126	36.14	27.83	1.299	364.0	5.8822	2140.96	0.840	-
P051	Early Earth - Archean Eon	29.7950	31.06	22.75	1.366	337.1	0.8413	283.58	0.986	-
P052	Early Earth - Great Oxidation Event	29.9340	30.61	22.30	1.373	316.8	1.3681	433.39	0.984	-
P053	Future Earth - Moist Greenhouse	26.1986	30.45	22.13	1.376	384.2	1.2114	465.44	1.052	NORM
P054	Future Earth - Dense CO2 Greenhouse	32.0917	33.14	24.82	1.335	368.8	4.9087	1810.11	0.950	-
P055	Future Earth - Steam Atmosphere	24.0576	33.82	25.51	1.326	465.6	6.1153	2847.58	1.097	-

Interpretation and flags

Topic	Interpretation
Preset status	World names and scenario labels identify application presets. No row-level observational validation or uncertainty estimates are claimed. Exoplanet, historical-Earth and future-Earth values are illustrative modelling choices.
Fixed heat capacity	C_p is fixed while real heat capacity varies with temperature. Very cold as well as hot scenarios can depart from this approximation. Rotational/vibrational excitation and chemical changes are not resolved by the fixed table [3, 4].
Pressure and phase	Non-ideal-gas behaviour, condensation, freezing, dissociation and ionization are outside this calculation. Venus and dense greenhouse cases require additional care. A computed value is not a confirmation that the stated mixture is a stable gas at the listed conditions.
Exospheres and vacuum	A finite c at very low pressure is a formal equation result. It does not establish continuum sound propagation. At P = 0 the equations give ρ = 0 and Z = 0; the finite sound-speed entry is retained as an application calculation.
Europa scenarios	The surface, ice-shell and subsurface-ocean presets are gas-mixture scenarios. Their outputs do not directly model wave propagation through solid ice or liquid water.
Brightness and absorption	B is a bounded audio-control mapping based on molar mass. This catalogue does not tabulate the nine-band absorption profiles, BaseLPF or temporal offsets described in the Technical Guide [1].
Flags	NORM: |raw total - 100| > 0.01 percentage points. ZERO-P: P = 0. LOW-P: 0 < P < 0.01 kPa. HIGH-T: T > 1000 °C. Thresholds are catalogue conventions, not physical validity boundaries. A dash means no listed flag applies.

Provenance and version information

Record	Basis and verification status
Preset snapshot	The supplied 55-preset catalogue records September 2026 inputs transcribed from WBP_GasComposition. This edition preserves those inputs. A fresh Blueprint export was not supplied for this update, so agreement with the latest build has not been certified.
Dataset and document	Dataset v1.1.0 identifies the unchanged preset snapshot. October 2026 identifies this document edition. The source catalogue records project v1.7.0 and Unreal Engine 5.8; those are historical source labels, not newly verified current-version claims.
Companion guide	Planetary Dispersion: Technical Guide v1.2, October 2026 [1], replaces the old v1.1 cross-reference. Sections 2.1–2.12 cover gas properties and brightness; Sections 2.13–2.14 cover the separate absorption-control model.
Calculation check	All 55 rows and 440 displayed derived values were independently recalculated using the published formulas and constants. Every displayed result agrees within its printed rounding precision; flag assignments also match the stated rules.
Source roles	The application snapshot supplies preset values and fixed model constants. CODATA [2] supports the universal gas constant, NIST [3] provides thermochemical reference data, and NASA [4] explains ideal-gas sound speed. These references do not validate the planetary presets or brightness mapping.

Machine-readable companion

The supplied catalogue links to **PlanetaryDispersion_55_Gas_Presets.csv**. It describes 55 rows with explicit gas fields, temperature, pressure and derived outputs. The live CSV has not been independently compared with this edition.

Download the linked 55-preset CSV

Regenerate the CSV and catalogue together whenever preset inputs or model constants change. Preserve the source export and record its build/version to make future comparisons reproducible.

Sources and further reading

References are linked and formatted consistently. Sources support the stated physical relationships and reference context; their use does not imply validation of every application value.

1. Portelli, D. (2026) *Planetary Dispersion: Technical Guide.* Version 1.2, October 2026. Companion guide used for this edition. Project resource page.

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