



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 07:30 AM UTC

PDB ID : 6ISG / pdb_00006isg
Title : Structure of 9N-I DNA polymerase incorporation with dG in the active site
Authors : Linwu, S.W.; Maestre-Reyna, M.; Tsai, M.D.; Tu, Y.H.; Chang, W.H.
Deposited on : 2018-11-16
Resolution : 3.40 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity : 4-5-2 with Phenix2.0
Mogul : 2022.3.0, CSD as543be (2022)
Xtriage (Phenix) : 2.0
EDS : 3.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4 : 9.0.010 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

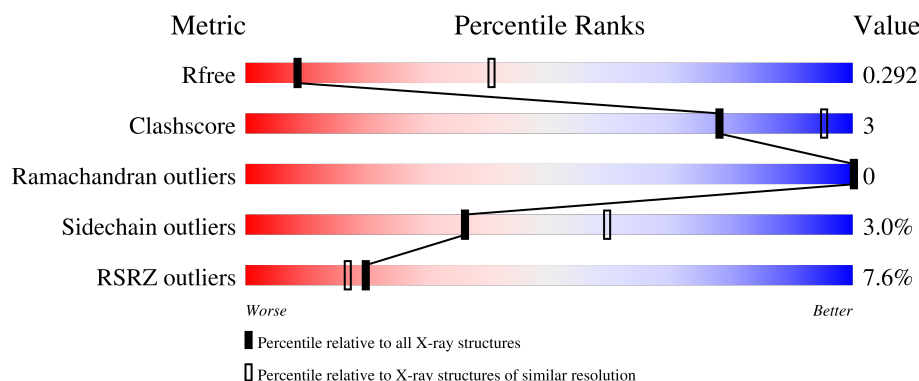
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.40 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	1001 (3.44-3.36)
Clashscore	190562	1022 (3.44-3.36)
Ramachandran outliers	187476	1012 (3.44-3.36)
Sidechain outliers	187428	1012 (3.44-3.36)
RSRZ outliers	180081	1001 (3.44-3.36)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	783	5% 91% 5%
2	C	15	60% 67% 33%
3	D	18	50% 78% 11% 11%

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 5922 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called DNA polymerase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	754	Total	C	N	O	S	0	0	0
			5245	3350	908	974	13			

There are 11 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	141	ALA	ASP	engineered mutation	UNP Q56366
A	143	ALA	GLU	engineered mutation	UNP Q56366
A	485	LEU	ALA	engineered mutation	UNP Q56366
A	776	LEU	-	expression tag	UNP Q56366
A	777	GLU	-	expression tag	UNP Q56366
A	778	HIS	-	expression tag	UNP Q56366
A	779	HIS	-	expression tag	UNP Q56366
A	780	HIS	-	expression tag	UNP Q56366
A	781	HIS	-	expression tag	UNP Q56366
A	782	HIS	-	expression tag	UNP Q56366
A	783	HIS	-	expression tag	UNP Q56366

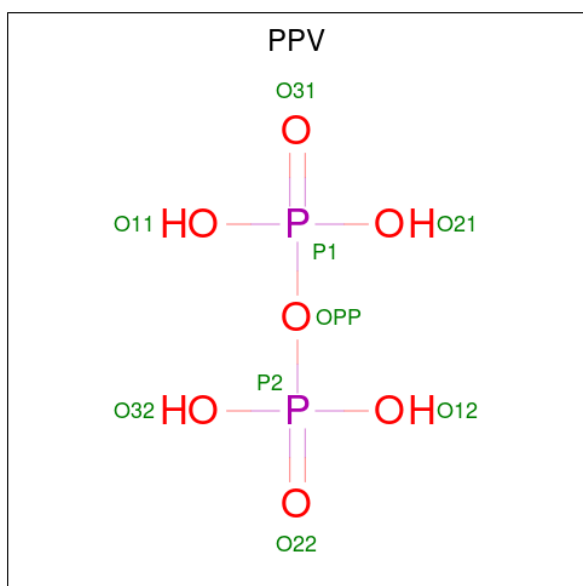
- Molecule 2 is a DNA chain called DNA (5'-D(*GP*CP*GP*GP*AP*CP*TP*GP*CP*TP*TP*AP*CP*CP*G)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	15	Total	C	N	O	P	0	0	0
			304	145	56	89	14			

- Molecule 3 is a DNA chain called DNA (5'-D(*GP*AP*CP*GP*GP*TP*AP*AP*GP*CP*AP*GP*TP*CP*CP*G)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	D	16	Total	C	N	O	P	0	0	0
			329	156	66	92	15			

- Molecule 4 is PYROPHOSPHATE (CCD ID: PPV) (formula: $\text{H}_4\text{O}_7\text{P}_2$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	O	P	0	0
			9	7	2		

- Molecule 5 is CALCIUM ION (CCD ID: CA) (formula: Ca).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	4	Total	Ca	0	0
			4	4		
5	D	1	Total	Ca	0	0
			1	1		

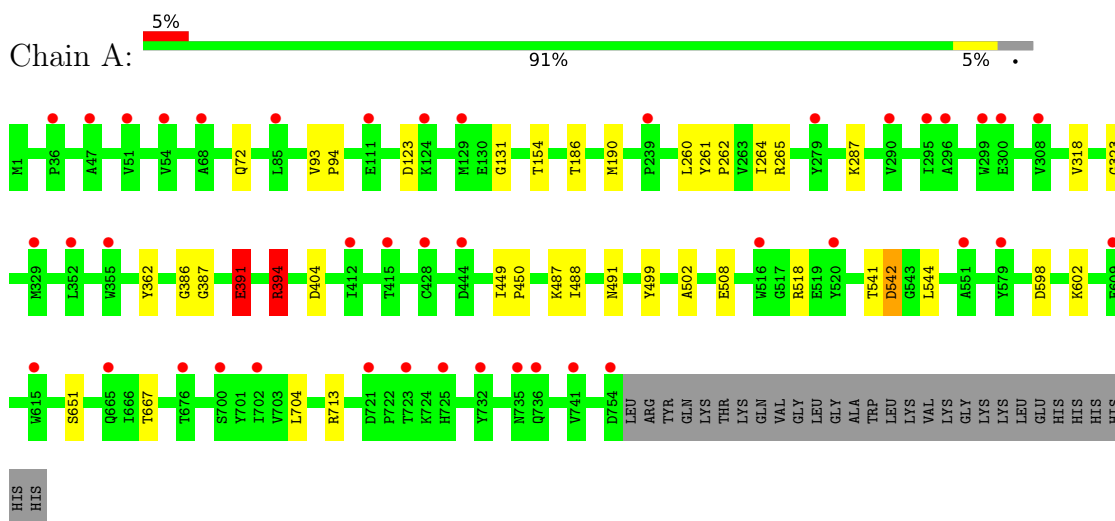
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	25	Total	O	0	0
			25	25		
6	C	1	Total	O	0	0
			1	1		
6	D	4	Total	O	0	0
			4	4		

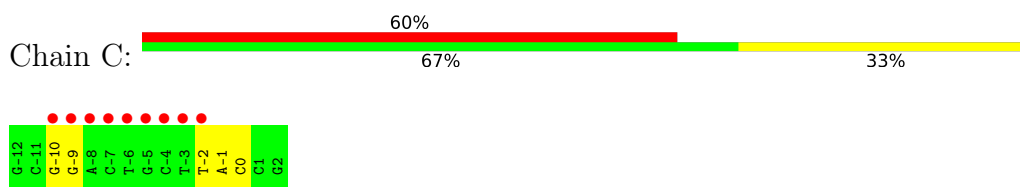
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

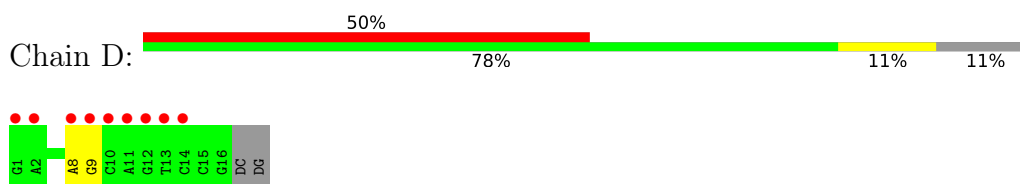
- Molecule 1: DNA polymerase



- Molecule 2: DNA (5'-D(*GP*CP*GP*GP*AP*CP*TP*GP*CP*TP*TP*AP*CP*CP*G)-3')



- Molecule 3: DNA (5'-D(*GP*AP*CP*GP*GP*TP*AP*AP*GP*CP*AP*GP*TP*CP*CP*G)-3')



4 Data and refinement statistics

Property	Value	Source
Space group	I 2 3	Depositor
Cell constants a, b, c, α , β , γ	208.08Å 208.08Å 208.08Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	40.81 – 3.40 40.81 – 3.40	Depositor EDS
% Data completeness (in resolution range)	99.9 (40.81-3.40) 99.9 (40.81-3.40)	Depositor EDS
R_{merge}	0.03	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.75 (at 3.40Å)	Xtriage
Refinement program	REFMAC 5.8.0238	Depositor
R, R_{free}	0.252 , 0.302 0.246 , 0.292	Depositor DCC
R_{free} test set	1073 reflections (5.18%)	wwPDB-VP
Wilson B-factor (Å ²)	139.9	Xtriage
Anisotropy	0.000	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 211.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.028 for -l,-k,-h	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	5922	wwPDB-VP
Average B, all atoms (Å ²)	157.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.19% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: PPV, CA

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	$\# Z > 5$	RMSZ	$\# Z > 5$
1	A	1.37	7/5374 (0.1%)	1.60	7/7346 (0.1%)
2	C	0.29	0/340	0.62	0/523
3	D	0.28	0/370	0.65	0/570
All	All	1.29	7/6084 (0.1%)	1.51	7/8439 (0.1%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	2

All (7) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	394	ARG	CD-NE	37.29	1.98	1.46
1	A	391	GLU	CD-OE1	33.62	1.89	1.25
1	A	394	ARG	CZ-NH1	29.66	1.74	1.32
1	A	394	ARG	NE-CZ	10.43	1.44	1.33
1	A	391	GLU	CB-CG	10.09	1.82	1.52
1	A	391	GLU	CD-OE2	8.83	1.42	1.25
1	A	391	GLU	CG-CD	6.03	1.67	1.52

All (7) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	391	GLU	CB-CG-CD	-18.59	81.00	112.60
1	A	394	ARG	NE-CZ-NH1	-13.11	108.39	121.50
1	A	394	ARG	CG-CD-NE	9.33	132.52	112.00

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	131	GLY	CA-C-O	-5.76	118.30	122.45
1	A	394	ARG	NE-CZ-NH2	5.62	124.26	119.20
1	A	394	ARG	CB-CG-CD	-5.55	98.53	111.30
1	A	391	GLU	OE1-CD-OE2	-5.16	110.51	122.90

There are no chirality outliers.

All (2) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	391	GLU	Sidechain
1	A	394	ARG	Sidechain

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	5245	0	4244	25	0
2	C	304	0	170	4	0
3	D	329	0	180	1	0
4	A	9	0	0	0	0
5	A	4	0	0	0	0
5	D	1	0	0	0	0
6	A	25	0	0	0	0
6	C	1	0	0	0	0
6	D	4	0	0	0	0
All	All	5922	0	4594	29	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 3.

All (29) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:391:GLU:CB	1:A:391:GLU:CG	1.82	1.54
1:A:394:ARG:NH1	1:A:394:ARG:CZ	1.74	1.50

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:394:ARG:NE	1:A:394:ARG:CD	1.98	1.26
1:A:391:GLU:OE1	1:A:391:GLU:CD	1.89	1.15
1:A:391:GLU:CB	1:A:391:GLU:CD	2.27	1.08
1:A:387:GLY:HA3	1:A:541:THR:HG21	1.54	0.88
1:A:387:GLY:HA3	1:A:541:THR:CG2	2.06	0.85
1:A:391:GLU:CD	1:A:391:GLU:HB2	2.01	0.83
3:D:8:DA:H2'	3:D:9:DG:C8	2.27	0.70
1:A:391:GLU:OE1	1:A:391:GLU:HB2	1.95	0.67
1:A:704:LEU:O	1:A:713:ARG:NH1	2.40	0.54
1:A:487:LYS:O	1:A:491:ASN:ND2	2.40	0.52
2:C:-1:DA:C2	2:C:0:DC:C2	2.98	0.51
1:A:386:GLY:O	1:A:518:ARG:NH1	2.41	0.51
1:A:544:LEU:C	1:A:544:LEU:HD12	2.35	0.51
1:A:449:ILE:HB	1:A:450:PRO:HD3	1.94	0.49
1:A:287:LYS:HD2	1:A:318:VAL:HG21	1.96	0.47
1:A:260:LEU:HD21	1:A:323:GLY:HA2	1.98	0.45
1:A:123:ASP:HA	1:A:362:TYR:CE2	2.53	0.44
1:A:404:ASP:OD1	1:A:404:ASP:C	2.60	0.44
1:A:93:VAL:N	1:A:94:PRO:HD2	2.34	0.43
1:A:598:ASP:OD1	1:A:602:LYS:N	2.50	0.43
1:A:499:TYR:CD2	1:A:502:ALA:HB2	2.53	0.43
2:C:-10:DG:H2''	2:C:-9:DG:N7	2.35	0.42
1:A:667:THR:OG1	2:C:-2:DT:OP2	2.32	0.42
1:A:261:TYR:N	1:A:262:PRO:HD2	2.35	0.41
2:C:-10:DG:H2''	2:C:-9:DG:C8	2.56	0.41
1:A:387:GLY:CA	1:A:541:THR:CG2	2.90	0.40
1:A:542:ASP:OD1	1:A:542:ASP:C	2.64	0.40

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	752/783 (96%)	702 (93%)	50 (7%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	366/675 (54%)	355 (97%)	11 (3%)	36	59

All (11) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	72	GLN
1	A	154	THR
1	A	186	THR
1	A	190	MET
1	A	264	ILE
1	A	265	ARG
1	A	391	GLU
1	A	488	ILE
1	A	508	GLU
1	A	542	ASP
1	A	651	SER

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	72	GLN
1	A	665	GLN
1	A	679	HIS
1	A	725	HIS

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 6 ligands modelled in this entry, 5 are monoatomic - leaving 1 for Mogul analysis.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\# Z > 2$	Counts	RMSZ	$\# Z > 2$
4	PPV	A	801	-	6,8,8	0.77	0	12,13,13	0.76	0

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
4	PPV	A	801	-	-	1/6/6/6	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	A	801	PPV	P2-OPP-P1-O31

There are no ring outliers.

No monomer is involved in short contacts.

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

In the following table, the column labelled ‘#RSRZ > 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q < 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	754/783 (96%)	0.26	42 (5%) 30 23	85, 129, 225, 302	0
2	C	15/15 (100%)	2.74	9 (60%) 0 0	121, 235, 640, 655	0
3	D	16/18 (88%)	2.01	9 (56%) 0 0	97, 193, 491, 532	0
All	All	785/816 (96%)	0.35	60 (7%) 20 17	85, 130, 251, 655	0

All (60) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	C	-5	DG	5.9
2	C	-4	DC	5.7
1	A	85	LEU	5.6
2	C	-8	DA	5.4
3	D	10	DC	5.2
1	A	736	GLN	5.2
1	A	300	GLU	5.0
3	D	9	DG	4.9
1	A	68	ALA	4.6
2	C	-6	DT	4.5
2	C	-3	DT	4.2
2	C	-7	DC	4.1
1	A	735	ASN	3.7
1	A	290	VAL	3.6
2	C	-9	DG	3.5
3	D	2	DA	3.4
1	A	36	PRO	3.4
1	A	51	VAL	3.3
1	A	299	TRP	3.0
3	D	8	DA	3.0
1	A	676	THR	3.0
1	A	428	CYS	2.9
1	A	723	THR	2.9

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Mol	Chain	Res	Type	RSRZ
1	A	295	ILE	2.9
1	A	615	TRP	2.9
3	D	12	DG	2.8
3	D	11	DA	2.8
1	A	732	TYR	2.7
1	A	415	THR	2.7
1	A	665	GLN	2.6
1	A	239	PRO	2.6
1	A	124	LYS	2.5
1	A	54	VAL	2.5
1	A	47	ALA	2.5
1	A	352	LEU	2.5
1	A	702	ILE	2.4
1	A	329	MET	2.4
1	A	609	GLU	2.4
1	A	279	TYR	2.4
3	D	1	DG	2.4
1	A	308	VAL	2.4
1	A	129	MET	2.3
1	A	444	ASP	2.3
1	A	412	ILE	2.3
1	A	296	ALA	2.3
2	C	-2	DT	2.3
1	A	741	VAL	2.2
1	A	355	TRP	2.2
1	A	551	ALA	2.2
2	C	-10	DG	2.2
3	D	13	DT	2.1
1	A	700	SER	2.1
1	A	754	ASP	2.1
1	A	579	TYR	2.1
1	A	111	GLU	2.1
1	A	725	HIS	2.1
1	A	516	TRP	2.0
1	A	520	TYR	2.0
1	A	721	ASP	2.0
3	D	14	DC	2.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
4	PPV	A	801	9/9	0.79	0.07	190,191,200,203	0
5	CA	A	805	1/1	0.84	0.07	189,189,189,189	0
5	CA	A	802	1/1	0.90	0.17	129,129,129,129	0
5	CA	A	804	1/1	0.91	0.10	177,177,177,177	0
5	CA	A	803	1/1	0.91	0.05	169,169,169,169	0
5	CA	D	101	1/1	0.91	0.14	168,168,168,168	0

6.5 Other polymers [i](#)

There are no such residues in this entry.