



# Full wwPDB X-ray Structure Validation Report ⓘ

Jan 31, 2016 – 09:55 PM GMT

PDB ID : 1RA2  
Title : DIHYDROFOLATE REDUCTASE COMPLEXED WITH FOLATE AND  
NICOTINAMIDE ADENINE DINUCLEOTIDE PHOSPHATE (OXIDIZED  
FORM)  
Authors : Sawaya, M.R.; Kraut, J.  
Deposited on : 1996-10-28  
Resolution : 1.60 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](mailto:validation@mail.wwpdb.org)  
A user guide is available at  
<http://wwpdb.org/validation/2016/XrayValidationReportHelp>  
with specific help available everywhere you see the ⓘ symbol.

---

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

MolProbity : 4.02b-467  
Mogul : 1.7 (RC4), CSD as536be (2015)  
Xtriage (Phenix) : 1.9-1692  
EDS : rb-20026688  
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)  
Refmac : 5.8.0135  
CCP4 : 6.5.0  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : trunk26865

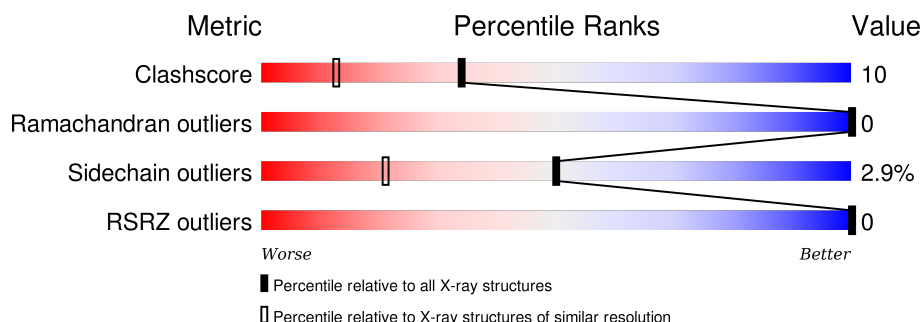
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 1.60 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))
Clashscore	102246	2732 (1.60-1.60)
Ramachandran outliers	100387	2654 (1.60-1.60)
Sidechain outliers	100360	2653 (1.60-1.60)
RSRZ outliers	91569	2479 (1.60-1.60)

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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. 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	159	 67% 30% .

## 2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 1486 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.

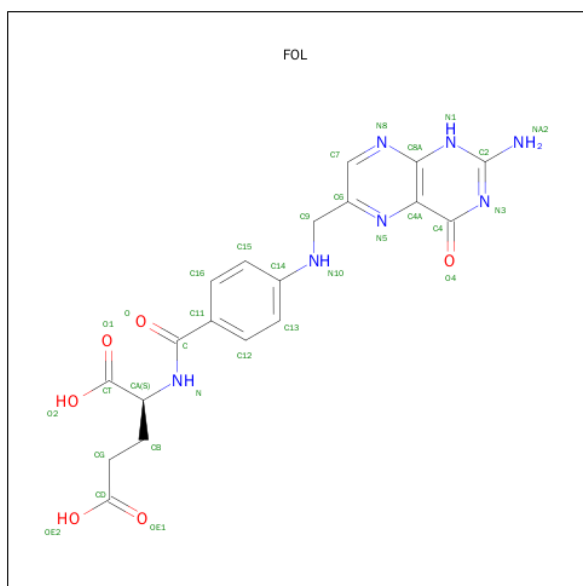
- Molecule 1 is a protein called DIHYDROFOLATE REDUCTASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	159	Total	C	N	O	S	13	0	0
			1268	805	216	240	7			

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	37	ASP	ASN	CONFLICT	UNP P0ABQ4

- Molecule 2 is FOLIC ACID (three-letter code: FOL) (formula: C<sub>19</sub>H<sub>19</sub>N<sub>7</sub>O<sub>6</sub>).





Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total	C	N	O	P	0	0
			48	21	7	17	3		

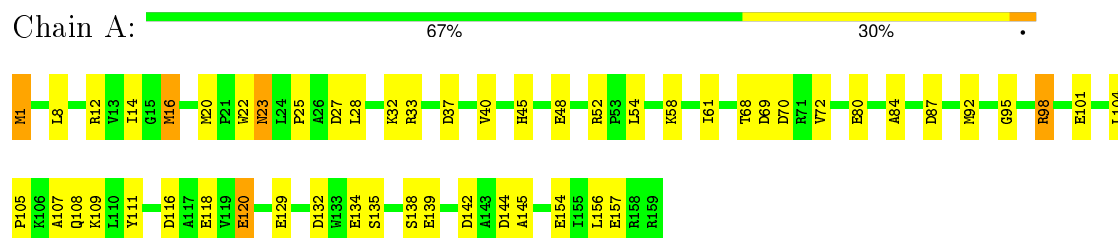
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	138	Total	O	0	0
			138	138		

### 3 Residue-property plots

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors 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 ( $\text{RSRZ} > 2$ ). 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: DIHYDROFOLATE REDUCTASE



## 4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	74.26Å 59.91Å 38.96Å 90.00° 107.63° 90.00°	Depositor
Resolution (Å)	20.00 – 1.60 19.22 – 1.60	Depositor EDS
% Data completeness (in resolution range)	95.0 (20.00-1.60) 94.5 (19.22-1.60)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	0.04	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.74 (at 1.60Å)	Xtriage
Refinement program	TNT V. 5-D	Depositor
R, $R_{free}$	0.171 , (Not available) 0.160 , (Not available)	Depositor DCC
$R_{free}$ test set	No test flags present.	DCC
Wilson B-factor (Å <sup>2</sup> )	15.6	Xtriage
Anisotropy	0.479	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.28 , 80.5	EDS
Estimated twinning fraction	No twinning to report.	Xtriage
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.48$ , $\langle L^2 \rangle = 0.31$	Xtriage
Outliers	0 of 20676 reflections	Xtriage
$F_o, F_c$ correlation	0.98	EDS
Total number of atoms	1486	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	24.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 10.49% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical values of  $\langle |L| \rangle$ ,  $\langle L^2 \rangle$  for acentric reflections are 0.5, 0.375 respectively for untwinned datasets, and 0.333, 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: FOL, NAP

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	1.31	10/1302 (0.8%)	1.63	25/1770 (1.4%)

All (10) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	134	GLU	CD-OE1	9.78	1.36	1.25
1	A	80	GLU	CD-OE1	9.57	1.36	1.25
1	A	101	GLU	CD-OE1	7.43	1.33	1.25
1	A	154	GLU	CD-OE1	7.13	1.33	1.25
1	A	139	GLU	CD-OE1	7.06	1.33	1.25
1	A	129	GLU	CD-OE1	6.25	1.32	1.25
1	A	157	GLU	CD-OE2	6.25	1.32	1.25
1	A	120	GLU	CD-OE2	5.78	1.32	1.25
1	A	48	GLU	CD-OE1	5.58	1.31	1.25
1	A	33	ARG	NE-CZ	5.26	1.39	1.33

All (25) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	12	ARG	NE-CZ-NH2	-10.79	114.90	120.30
1	A	37	ASP	CB-CG-OD2	-9.91	109.38	118.30
1	A	12	ARG	NE-CZ-NH1	9.36	124.98	120.30
1	A	87	ASP	CB-CG-OD1	-8.68	110.49	118.30
1	A	8	LEU	CB-CA-C	-8.67	93.73	110.20
1	A	37	ASP	CB-CG-OD1	8.53	125.97	118.30
1	A	144	ASP	CB-CG-OD2	-8.37	110.77	118.30
1	A	69	ASP	CB-CG-OD2	-8.29	110.84	118.30
1	A	87	ASP	CB-CG-OD2	8.08	125.57	118.30
1	A	132	ASP	CB-CG-OD1	7.96	125.46	118.30
1	A	33	ARG	NE-CZ-NH1	7.83	124.21	120.30

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	132	ASP	CB-CG-OD2	-7.78	111.29	118.30
1	A	1	MET	CA-CB-CG	-7.57	100.44	113.30
1	A	98	ARG	NE-CZ-NH1	7.36	123.98	120.30
1	A	138	SER	N-CA-CB	6.98	120.97	110.50
1	A	27	ASP	CB-CG-OD2	-6.71	112.26	118.30
1	A	107	ALA	N-CA-CB	-6.66	100.77	110.10
1	A	52	ARG	NE-CZ-NH1	6.29	123.45	120.30
1	A	69	ASP	CB-CG-OD1	5.83	123.55	118.30
1	A	145	ALA	CB-CA-C	-5.61	101.69	110.10
1	A	116	ASP	CB-CG-OD2	5.53	123.28	118.30
1	A	144	ASP	CB-CG-OD1	5.41	123.17	118.30
1	A	70	ASP	CB-CG-OD2	-5.36	113.48	118.30
1	A	142	ASP	CB-CG-OD1	-5.33	113.51	118.30
1	A	116	ASP	CB-CG-OD1	-5.08	113.73	118.30

There are no chirality outliers.

There are no planarity outliers.

## 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	1268	0	1221	26	0
2	A	32	0	16	0	0
3	A	48	0	25	3	0
4	A	138	0	0	5	0
All	All	1486	0	1262	26	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 10.

All (26) 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:108:GLN:HG2	4:A:647:HOH:O	1.83	0.79
1:A:1:MET:HE2	1:A:108:GLN:HB2	1.70	0.73

*Continued on next page...*



Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:104:LEU:HB3	1:A:105:PRO:HD3	1.72	0.70
1:A:61:ILE:HD12	1:A:61:ILE:N	2.07	0.70
1:A:23:ASN:ND2	4:A:655:HOH:O	2.30	0.65
1:A:109:LYS:HE2	1:A:111:TYR:CZ	2.32	0.64
1:A:1:MET:CE	1:A:108:GLN:HB2	2.29	0.63
1:A:68:THR:HA	4:A:626:HOH:O	2.02	0.57
1:A:135:SER:HA	1:A:156:LEU:HD23	1.85	0.57
1:A:32:LYS:NZ	4:A:675:HOH:O	2.44	0.50
1:A:120:GLU:HA	1:A:120:GLU:OE1	2.12	0.49
1:A:20:MET:HE2	1:A:22:TRP:CH2	2.49	0.48
1:A:40:VAL:O	1:A:40:VAL:HG23	2.15	0.46
1:A:45:HIS:HE1	4:A:636:HOH:O	1.98	0.46
1:A:61:ILE:HD13	1:A:72:VAL:CG2	2.44	0.46
1:A:40:VAL:HA	1:A:92:MET:O	2.15	0.45
1:A:20:MET:CE	1:A:22:TRP:CH2	3.00	0.45
1:A:98:ARG:NH1	3:A:164:NAP:H3B	2.33	0.43
1:A:104:LEU:N	1:A:105:PRO:CD	2.81	0.43
1:A:28:LEU:HD23	1:A:28:LEU:HA	1.94	0.42
1:A:95:GLY:HA3	3:A:164:NAP:H5N	2.00	0.42
1:A:58:LYS:HE3	1:A:84:ALA:O	2.19	0.42
1:A:14:ILE:O	3:A:164:NAP:H2N	2.20	0.41
1:A:16:MET:CG	1:A:20:MET:SD	3.09	0.41
1:A:61:ILE:CD1	1:A:61:ILE:N	2.80	0.40
1:A:54:LEU:HD23	1:A:54:LEU:HA	1.91	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	157/159 (99%)	156 (99%)	1 (1%)	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	136/136 (100%)	132 (97%)	4 (3%)	50 21

All (4) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	16	MET
1	A	23	ASN
1	A	25	PRO
1	A	118	GLU

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

Mol	Chain	Res	Type
1	A	23	ASN
1	A	45	HIS
1	A	65	GLN
1	A	146	GLN

### 5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

## 5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

## 5.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 5.6 Ligand geometry

2 ligands are modelled in this entry.

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
2	FOL	A	161	-	27,34,34	2.47	12 (44%)	31,47,47	2.53	12 (38%)
3	NAP	A	164	-	42,52,52	2.81	13 (30%)	54,80,80	3.27	19 (35%)

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
2	FOL	A	161	-	-	0/16/22/22	0/3/3/3
3	NAP	A	164	-	-	0/27/67/67	0/5/5/5

All (25) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	161	FOL	C11-C	-4.73	1.40	1.50
2	A	161	FOL	C-N	-4.61	1.23	1.34
3	A	164	NAP	C2N-C3N	-4.02	1.32	1.39
3	A	164	NAP	C6N-C5N	-3.83	1.30	1.38
3	A	164	NAP	C3N-C7N	-3.61	1.44	1.50
2	A	161	FOL	C2-NA2	-3.46	1.26	1.34
3	A	164	NAP	C8A-N7A	-2.64	1.29	1.34
2	A	161	FOL	C15-C14	-2.48	1.35	1.39
3	A	164	NAP	PA-O2A	-2.26	1.45	1.54
3	A	164	NAP	O2D-C2D	-2.12	1.37	1.43
2	A	161	FOL	C16-C15	2.06	1.42	1.38
3	A	164	NAP	C3D-C4D	2.08	1.58	1.53
2	A	161	FOL	C16-C11	2.19	1.43	1.39
2	A	161	FOL	C13-C14	2.36	1.43	1.39
3	A	164	NAP	C7N-N7N	2.48	1.38	1.33
3	A	164	NAP	C5D-C4D	2.50	1.59	1.51

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	161	FOL	C8A-N8	2.62	1.41	1.37
2	A	161	FOL	C2-N3	3.08	1.40	1.35
3	A	164	NAP	P2B-O2B	4.11	1.72	1.60
2	A	161	FOL	C4-C4A	4.23	1.49	1.41
2	A	161	FOL	C4A-N5	4.27	1.40	1.33
2	A	161	FOL	C8A-N1	4.44	1.44	1.36
3	A	164	NAP	O4D-C1D	5.55	1.48	1.41
3	A	164	NAP	C5N-C4N	6.75	1.52	1.38
3	A	164	NAP	C4N-C3N	11.40	1.58	1.39

All (31) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	164	NAP	O7N-C7N-C3N	-12.60	105.83	119.59
3	A	164	NAP	C5N-C4N-C3N	-8.03	110.24	120.33
2	A	161	FOL	N1-C2-N3	-5.58	118.95	127.44
2	A	161	FOL	C4A-C4-N3	-5.19	116.49	123.59
2	A	161	FOL	C13-C14-N10	-3.90	113.58	121.06
2	A	161	FOL	CB-CG-CD	-3.83	97.39	113.02
2	A	161	FOL	C4-C4A-C8A	-3.48	117.71	119.94
3	A	164	NAP	O4D-C4D-C3D	-3.03	99.03	105.15
2	A	161	FOL	O-C-N	-3.00	117.01	122.44
2	A	161	FOL	C16-C15-C14	-2.81	117.13	120.28
3	A	164	NAP	C1B-N9A-C4A	-2.76	122.78	126.94
3	A	164	NAP	O5B-PA-O1A	-2.66	99.28	109.62
3	A	164	NAP	O4B-C4B-C3B	-2.47	100.18	105.15
3	A	164	NAP	O2B-P2B-O1X	-2.44	101.01	107.11
3	A	164	NAP	C3B-C2B-C1B	-2.42	98.05	102.73
2	A	161	FOL	C7-N8-C8A	-2.13	114.41	116.93
3	A	164	NAP	O2A-PA-O1A	2.14	124.12	112.53
3	A	164	NAP	C5N-C6N-N1N	2.27	124.40	120.47
2	A	161	FOL	O-C-C11	2.30	124.91	120.97
3	A	164	NAP	O2N-PN-O3	2.34	115.69	105.09
3	A	164	NAP	O2D-C2D-C3D	2.54	120.08	111.83
3	A	164	NAP	C4B-O4B-C1B	2.56	112.53	109.72
2	A	161	FOL	C15-C14-N10	2.63	126.09	121.06
3	A	164	NAP	O3X-P2B-O1X	2.66	119.13	110.58
3	A	164	NAP	O3D-C3D-C4D	2.82	119.50	111.05
2	A	161	FOL	NA2-C2-N1	3.23	123.99	117.80
3	A	164	NAP	C6N-C5N-C4N	3.27	124.39	119.44
3	A	164	NAP	C5D-C4D-C3D	4.31	132.33	115.21
2	A	161	FOL	C4-N3-C2	6.27	124.64	115.94

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Res	Type	Atoms	Z	Observed( $^{\circ}$ )	Ideal( $^{\circ}$ )
3	A	164	NAP	C3N-C2N-N1N	7.86	129.42	120.36
3	A	164	NAP	C3N-C7N-N7N	11.75	130.68	117.82

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	164	NAP	3	0

## 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 [i](#)

### 6.1 Protein, DNA and RNA chains [i](#)

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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	A	159/159 (100%)	-0.67	0 100 100	9, 19, 39, 63	5 (3%)

There are no RSRZ outliers to report.

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

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

### 6.3 Carbohydrates [i](#)

There are no carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. The B-factors column lists the minimum, median, 95<sup>th</sup> 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	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
2	FOL	A	161	32/32	0.96	0.07	0.03	11,19,66,76	0
3	NAP	A	164	48/48	0.98	0.06	-0.20	9,19,40,42	0

### 6.5 Other polymers [i](#)

There are no such residues in this entry.