wwPDB X-ray Structure Validation Summary Report (i)

Feb 5, 2025 – 03:44 pm GMT

PDB ID	:	9EZ4
Title	:	Complex of a mutant of the SARS-CoV-2 main protease Mpro with the nsp5/6 substrate peptide.
Authors	:	Battistutta, R.; Fornasier, E.; Giachin, G.
Deposited on	:	2024-04-10
Resolution	:	1.80 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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 (i) 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 (1)) were used in the production of this report:

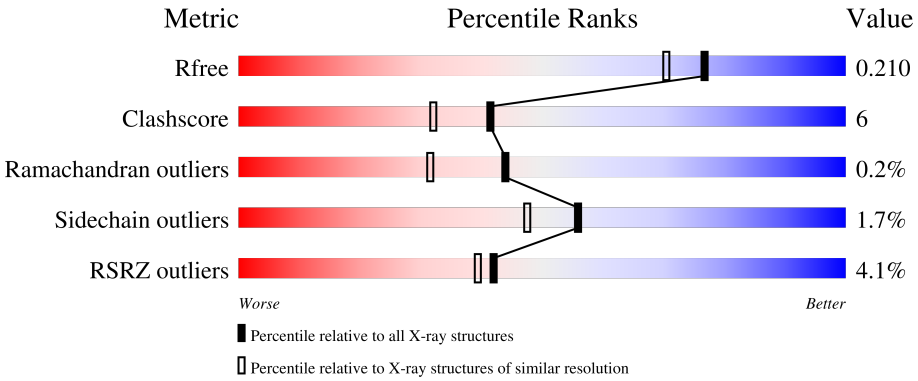
MolProbity	:	4.02b-467
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	1.13
EDS	:	3.0
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.003 (Gargrove)
Density-Fitness	:	1.0.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.40

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 1.80 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}	164625	7108 (1.80-1.80)
Clashscore	180529	8162 (1.80-1.80)
Ramachandran outliers	177936	8077 (1.80-1.80)
Sidechain outliers	177891	8076 (1.80-1.80)
RSRZ outliers	164620	7108 (1.80-1.80)

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 <=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	306	2% 88% 10%
2	B	306	6% 86% 10%
3	C	11	18% 36% 36% 27%

2 Entry composition (i)

There are 7 unique types of molecules in this entry. The entry contains 9800 atoms, of which 4696 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 Replicase polyprotein 1a.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	301	Total	C	H	N	O	S	0	4	0
			4631	1479	2291	396	442	23			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	41	ALA	HIS	conflict	UNP A0A8B1KJN1
A	145	ALA	CYS	conflict	UNP A0A8B1KJN1

- Molecule 2 is a protein called Non-structural protein 7.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
2	B	299	Total	C	H	N	O	S	0	6	0
			4613	1476	2284	397	436	20			

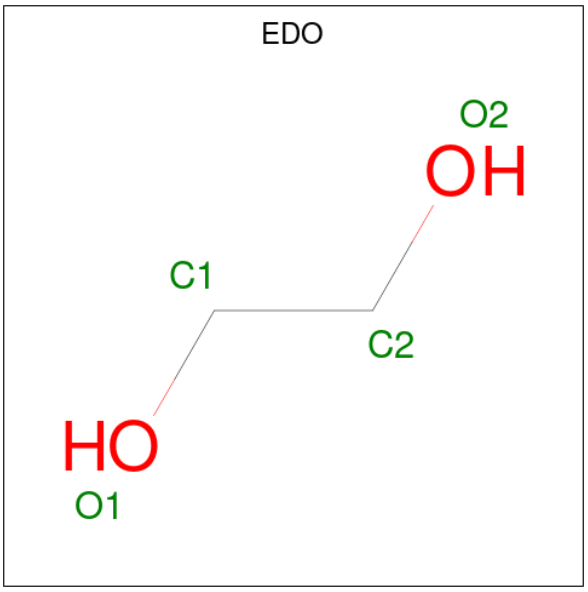
There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	41	ALA	HIS	conflict	UNP P0DTD1
B	145	ALA	CYS	conflict	UNP P0DTD1

- Molecule 3 is a protein called GLY-VAL-THR-PHE-GLN-SER-ALA-VAL.

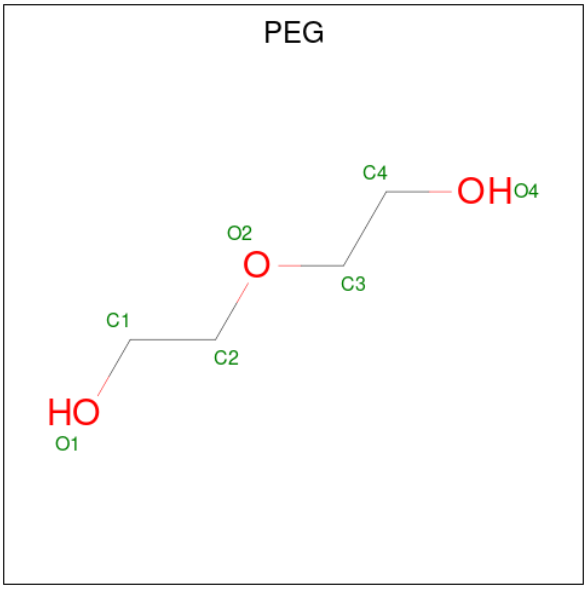
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	C	8	Total	C	H	N	O	0	2	0
			131	45	64	10	12			

- Molecule 4 is 1,2-ETHANEDIOL (three-letter code: EDO) (formula: $C_2H_6O_2$).



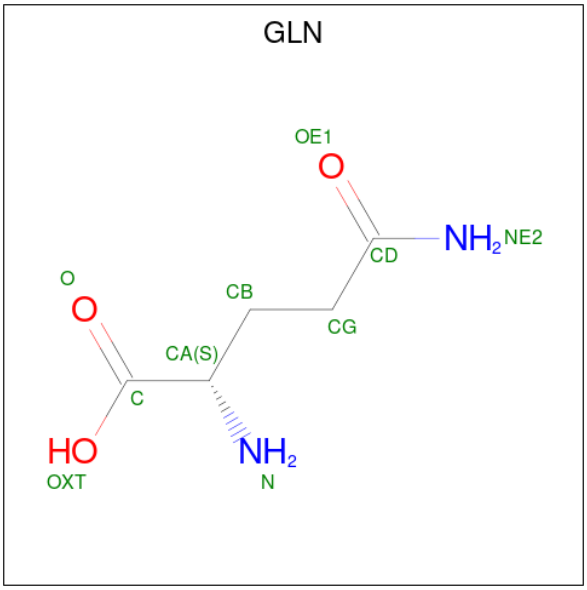
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	1	Total C H O 10 2 6 2	0	0
4	A	1	Total C H O 10 2 6 2	0	0
4	A	1	Total C H O 10 2 6 2	0	0
4	A	1	Total C H O 10 2 6 2	0	0
4	B	1	Total C H O 10 2 6 2	0	0

- Molecule 5 is DI(HYDROXYETHYL)ETHER (three-letter code: PEG) (formula: $C_4H_{10}O_3$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	1	Total C H O 17 4 10 3	0	0
5	B	1	Total C H O 17 4 10 3	0	0

- Molecule 6 is GLUTAMINE (three-letter code: GLN) (formula: $C_5H_{10}N_2O_3$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
6	B	1	Total C H N O 16 5 7 2 2	0	0

- Molecule 7 is water.

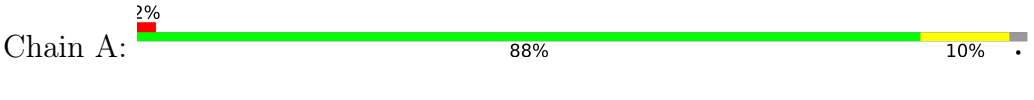
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
7	A	209	Total O 209 209	0	0
7	B	111	Total O 111 111	0	0
7	C	5	Total O 5 5	0	0

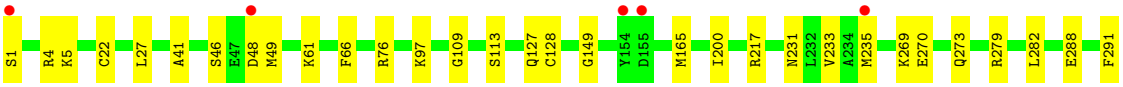
3 Residue-property plots (i)

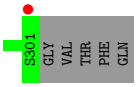
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. 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: Replicase polyprotein 1a

Chain A:

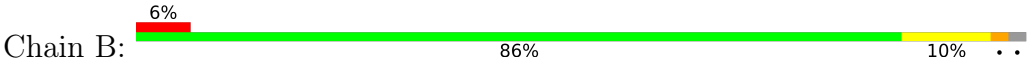


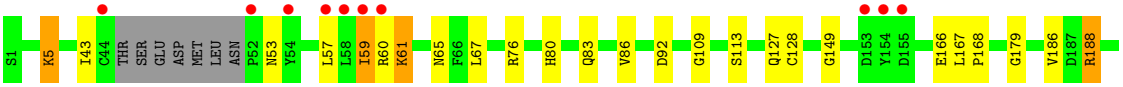


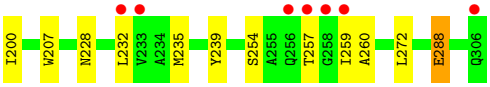


• Molecule 2: Non-structural protein 7

Chain B:

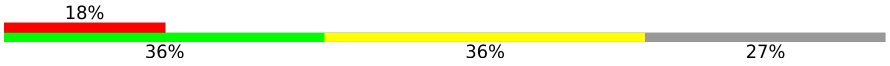






• Molecule 3: GLY-VAL-THR-PHE-GLN-SER-ALA-VAL

Chain C:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	67.75Å 99.04Å 101.99Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	44.54 – 1.80 44.54 – 1.80	Depositor EDS
% Data completeness (in resolution range)	99.4 (44.54-1.80) 99.5 (44.54-1.80)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	0.08	Depositor
$< I/\sigma(I) >$ [1]	1.27 (at 1.79Å)	Xtriage
Refinement program	PHENIX 1.20.1_4487	Depositor
R, R_{free}	0.183 , 0.215 0.179 , 0.210	Depositor DCC
R_{free} test set	3187 reflections (4.96%)	wwPDB-VP
Wilson B-factor (Å^2)	32.0	Xtriage
Anisotropy	0.297	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.41 , 42.9	EDS
L-test for twinning[2]	$< \|L\| > = 0.50$, $< L^2 > = 0.34$	Xtriage
Estimated twinning fraction	0.008 for -h,l,k	Xtriage
F_o,F_c correlation	0.97	EDS
Total number of atoms	9800	wwPDB-VP
Average B, all atoms (Å^2)	44.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.06% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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: OCS, PEG, EDO

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	0.68	0/2393	0.79	0/3250
2	B	0.61	0/2400	0.73	0/3259
3	C	0.63	0/77	0.89	0/103
All	All	0.65	0/4870	0.76	0/6612

There are no bond length outliers.

There are no bond angle outliers.

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	2340	2291	2275	32	0
2	B	2329	2284	2266	28	0
3	C	67	64	55	9	0
4	A	16	24	24	0	0
4	B	4	6	6	0	0
5	A	7	10	10	2	0
5	B	7	10	10	0	0
6	B	9	7	7	0	0
7	A	209	0	0	8	0
7	B	111	0	0	3	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
7	C	5	0	0	1	0
All	All	5104	4696	4653	60	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 6.

The worst 5 of 60 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:76:ARG:HD3	7:A:557:HOH:O	1.42	1.16
2:B:59:ILE:O	2:B:59:ILE:HG22	1.64	0.98
1:A:41:ALA:HB3	3:C:5[B]:PHE:CZ	2.12	0.84
2:B:59:ILE:O	2:B:59:ILE:CG2	2.34	0.73
2:B:254:SER:OG	2:B:260:ALA:HA	1.92	0.69

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	302/306 (99%)	295 (98%)	7 (2%)	0	100 100
2	B	301/306 (98%)	295 (98%)	5 (2%)	1 (0%)	37 25
3	C	8/11 (73%)	6 (75%)	2 (25%)	0	100 100
All	All	611/623 (98%)	596 (98%)	14 (2%)	1 (0%)	44 31

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
2	B	59	ILE

5.3.2 Protein sidechains (i)

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	259/260 (100%)	257 (99%)	2 (1%)	79 76
2	B	258/261 (99%)	251 (97%)	7 (3%)	40 28
3	C	8/9 (89%)	8 (100%)	0	100 100
All	All	525/530 (99%)	516 (98%)	9 (2%)	56 47

5 of 9 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
2	B	188	ARG
2	B	288	GLU
2	B	53	ASN
2	B	60	ARG
2	B	61	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

5.3.3 RNA (i)

There are no RNA molecules in this entry.

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

1 non-standard protein/DNA/RNA residue is 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	$\#\|Z\|>2$
1	OCS	A	156	1	7,8,9	0.80	0	6,11,13	1.13	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
1	OCS	A	156	1	-	1/4/7/9	-

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
1	A	156	OCS	N-CA-CB-SG

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates (i)

There are no oligosaccharides in this entry.

5.6 Ligand geometry (i)

8 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	$\#\|Z\|>2$
4	EDO	A	402	-	3,3,3	0.57	0	2,2,2	0.24	0

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\#\|Z\|>2$	Counts	RMSZ	$\#\|Z\|>2$
4	EDO	A	404	-	3,3,3	0.60	0	2,2,2	0.25	0
6	GLN	B	403	-	7,8,9	1.00	0	4,9,11	0.28	0
4	EDO	A	401	-	3,3,3	0.49	0	2,2,2	0.32	0
5	PEG	A	405	-	6,6,6	0.24	0	5,5,5	0.06	0
5	PEG	B	402	-	6,6,6	0.16	0	5,5,5	0.22	0
4	EDO	B	401	-	3,3,3	0.63	0	2,2,2	0.14	0
4	EDO	A	403	-	3,3,3	0.62	0	2,2,2	0.04	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	EDO	A	402	-	-	0/1/1/1	-
4	EDO	A	404	-	-	0/1/1/1	-
6	GLN	B	403	-	-	0/6/7/9	-
4	EDO	A	401	-	-	1/1/1/1	-
5	PEG	A	405	-	-	1/4/4/4	-
5	PEG	B	402	-	-	3/4/4/4	-
4	EDO	B	401	-	-	1/1/1/1	-
4	EDO	A	403	-	-	0/1/1/1	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

5 of 6 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	A	405	PEG	O2-C3-C4-O4
5	B	402	PEG	O2-C3-C4-O4
5	B	402	PEG	O1-C1-C2-O2
5	B	402	PEG	C4-C3-O2-C2
4	A	401	EDO	O1-C1-C2-O2

There are no ring outliers.

1 monomer is involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	A	405	PEG	2	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

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, 95^{th} 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	300/306 (98%)	-0.16	6 (2%)	64	63	21, 38, 62, 104	2 (0%)
2	B	299/306 (97%)	0.27	17 (5%)	30	28	20, 44, 78, 119	3 (1%)
3	C	8/11 (72%)	1.23	2 (25%)	2	1	17, 41, 66, 83	1 (12%)
All	All	607/623 (97%)	0.07	25 (4%)	42	39	17, 41, 71, 119	6 (0%)

The worst 5 of 25 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	B	54	TYR	4.6
2	B	59	ILE	4.5
3	C	9	VAL	4.5
2	B	154	TYR	3.8
1	A	48	ASP	3.5

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

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, 95^{th} 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(Å^2)	Q<0.9
1	OCS	A	156	9/10	0.86	0.13	32,48,57,59	0

6.3 Carbohydrates

There are no monosaccharides 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, 95^{th} 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(Å^2)	Q<0.9
5	PEG	B	402	7/7	0.77	0.19	61,77,92,94	0
4	EDO	A	403	4/4	0.79	0.16	60,72,76,85	0
5	PEG	A	405	7/7	0.80	0.16	49,65,75,77	0
4	EDO	A	404	4/4	0.80	0.17	58,69,78,83	0
4	EDO	B	401	4/4	0.83	0.17	60,72,79,79	0
6	GLN	B	403	9/10	0.83	0.15	40,53,61,64	0
4	EDO	A	402	4/4	0.88	0.12	49,63,78,78	0
4	EDO	A	401	4/4	0.91	0.10	48,57,64,70	0

6.5 Other polymers (i)

There are no such residues in this entry.