



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 6, 2026 – 01:48 PM UTC

PDB ID : 2ZAD / pdb_00002zad
Title : Crystal Structure of Muconate Cycloisomerase from *Thermotoga maritima* MSB8
Authors : Padmanabhan, B.; Bessho, Y.; Yokoyama, S.; RIKEN Structural Genomics/Proteomics Initiative (RSGI)
Deposited on : 2007-10-03
Resolution : 1.60 Å(reported)

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

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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

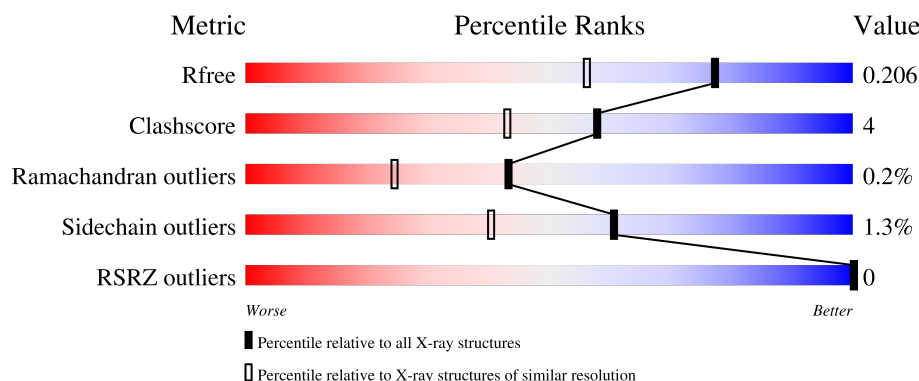
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 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))
R_{free}	180053	4673 (1.60-1.60)
Clashscore	190562	4931 (1.60-1.60)
Ramachandran outliers	187476	4831 (1.60-1.60)
Sidechain outliers	187428	4830 (1.60-1.60)
RSRZ outliers	180081	4672 (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 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	345	91% 8%
1	B	345	90% 10%
1	C	345	89% 10%
1	D	345	93% 6%

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard

residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	1PE	D	348	-	-	X	-
4	PEG	A	351	-	-	X	-

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 12336 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.

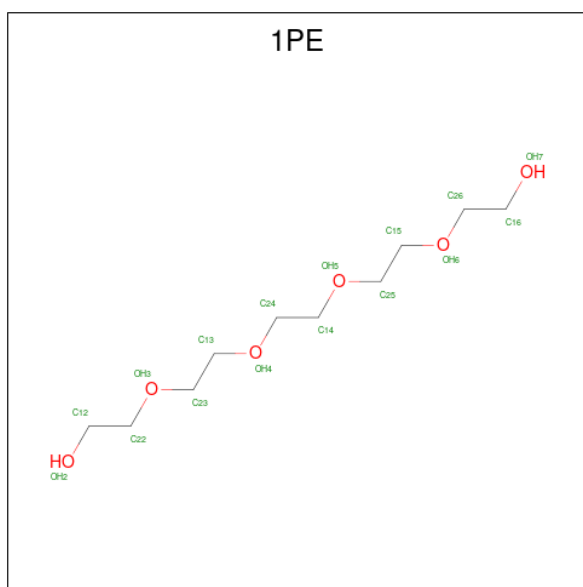
- Molecule 1 is a protein called Muconate cycloisomerase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	344	Total	C	N	O	S	Se	0	6	0
			2734	1734	470	520	2	8			
1	B	344	Total	C	N	O	S	Se	0	8	0
			2742	1743	470	519	2	8			
1	C	344	Total	C	N	O	S	Se	0	5	0
			2729	1733	467	519	2	8			
1	D	344	Total	C	N	O	S	Se	0	4	0
			2720	1726	466	518	2	8			

- Molecule 2 is MANGANESE (II) ION (CCD ID: MN) (formula: Mn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Mn	0	0
			1	1		
2	B	1	Total	Mn	0	0
			1	1		
2	C	1	Total	Mn	0	0
			1	1		
2	D	1	Total	Mn	0	0
			1	1		

- Molecule 3 is PENTAETHYLENE GLYCOL (CCD ID: 1PE) (formula: C₁₀H₂₂O₆).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			16	10	6		
3	A	1	Total	C	O	0	0
			16	10	6		
3	A	1	Total	C	O	0	0
			13	8	5		
3	B	1	Total	C	O	0	0
			16	10	6		
3	B	1	Total	C	O	0	0
			13	8	5		
3	C	1	Total	C	O	0	0
			16	10	6		
3	C	1	Total	C	O	0	0
			13	8	5		
3	C	1	Total	C	O	0	0
			10	6	4		
3	D	1	Total	C	O	0	0
			16	10	6		
3	D	1	Total	C	O	0	0
			16	10	6		
3	D	1	Total	C	O	0	0
			16	10	6		

- Molecule 4 is DI(HYDROXYETHYL)ETHER (CCD ID: PEG) (formula: C₄H₁₀O₃).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	0	0
			7	4	3		
4	A	1	Total	C	O	0	0
			7	4	3		
4	B	1	Total	C	O	0	0
			7	4	3		
4	D	1	Total	C	O	0	0
			7	4	3		

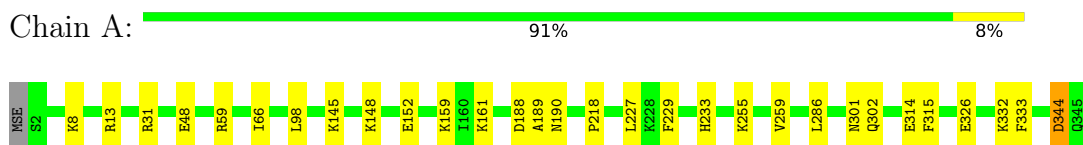
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	292	Total	O	0	0
			292	292		
5	B	313	Total	O	0	0
			313	313		
5	C	321	Total	O	0	0
			321	321		
5	D	292	Total	O	0	0
			292	292		

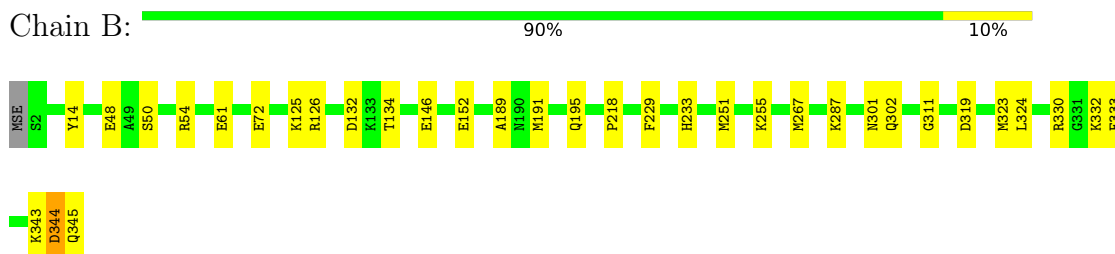
3 Residue-property plots

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.

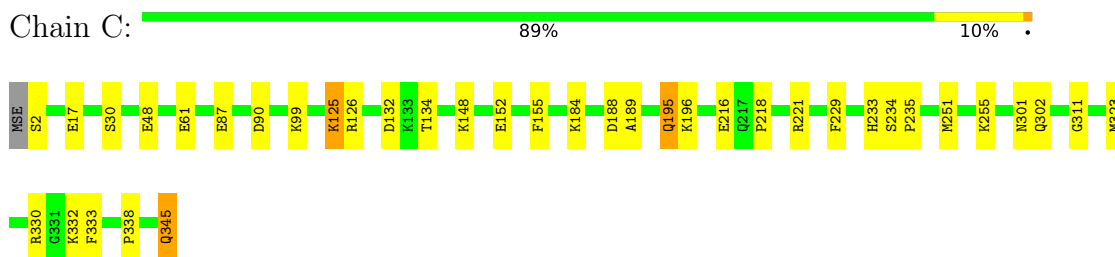
- Molecule 1: Muconate cycloisomerase



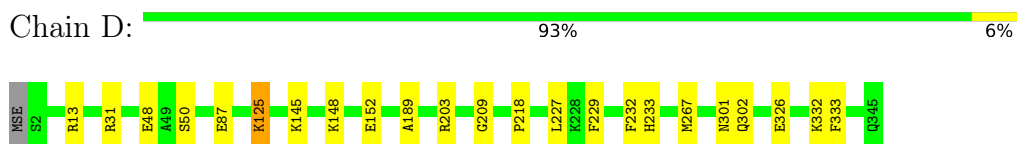
- Molecule 1: Muconate cycloisomerase



- Molecule 1: Muconate cycloisomerase



- Molecule 1: Muconate cycloisomerase



4 Data and refinement statistics

Property	Value	Source
Space group	P 4	Depositor
Cell constants a, b, c, α , β , γ	112.77Å 112.77Å 122.53Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	20.00 – 1.60 20.00 – 1.60	Depositor EDS
% Data completeness (in resolution range)	97.7 (20.00-1.60) 97.7 (20.00-1.60)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.59 (at 1.60Å)	Xtriage
Refinement program	REFMAC 5.2.0019	Depositor
R, R_{free}	0.175 , 0.201 0.181 , 0.206	Depositor DCC
R_{free} test set	9901 reflections (4.92%)	wwPDB-VP
Wilson B-factor (Å ²)	14.0	Xtriage
Anisotropy	0.344	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 37.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.447 for h,-k,-l	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	12336	wwPDB-VP
Average B, all atoms (Å ²)	21.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.73% 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 [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: 1PE, PEG, MN

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	0.53	0/2779	0.74	0/3717
1	B	0.56	0/2797	0.75	0/3742
1	C	0.55	0/2775	0.76	0/3713
1	D	0.55	0/2763	0.74	0/3698
All	All	0.55	0/11114	0.75	0/14870

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	B	0	1

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	B	344	ASP	Peptide

5.2 Too-close contacts [i](#)

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	2734	0	2779	23	0
1	B	2742	0	2803	24	1
1	C	2729	0	2775	32	0
1	D	2720	0	2761	19	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
2	C	1	0	0	0	0
2	D	1	0	0	0	0
3	A	45	0	61	4	0
3	B	29	0	39	2	0
3	C	39	0	52	6	0
3	D	48	0	66	10	0
4	A	14	0	20	4	0
4	B	7	0	10	0	0
4	D	7	0	10	0	0
5	A	292	0	0	3	1
5	B	313	0	0	5	0
5	C	321	0	0	7	1
5	D	292	0	0	5	0
All	All	12336	0	11376	101	2

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 4.

The worst 5 of 101 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:C:255:LYS:HG3	5:C:510:HOH:O	1.59	1.03
1:C:134:THR:HB	1:C:323:MSE:HE1	1.42	1.00
1:C:184:LYS:HZ3	3:C:349:1PE:H142	1.30	0.97
1:D:232:PHE:HB3	3:D:348:1PE:H131	1.50	0.94
1:B:134:THR:HB	1:B:323:MSE:HE1	1.57	0.87

All (2) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:255:LYS:NZ	5:A:526:HOH:O[4_565]	1.96	0.24
5:C:460:HOH:O	5:C:647:HOH:O[3_555]	2.14	0.06

5.3 Torsion angles

5.3.1 Protein backbone

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	348/345 (101%)	333 (96%)	13 (4%)	2 (1%)	21	7
1	B	350/345 (101%)	332 (95%)	18 (5%)	0	100	100
1	C	347/345 (101%)	333 (96%)	14 (4%)	0	100	100
1	D	346/345 (100%)	331 (96%)	14 (4%)	1 (0%)	36	20
All	All	1391/1380 (101%)	1329 (96%)	59 (4%)	3 (0%)	43	24

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	D	326	GLU
1	A	326	GLU
1	A	344	ASP

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	295/283 (104%)	293 (99%)	2 (1%)	76	63
1	B	297/283 (105%)	293 (99%)	4 (1%)	61	40
1	C	294/283 (104%)	287 (98%)	7 (2%)	43	19
1	D	293/283 (104%)	291 (99%)	2 (1%)	76	63
All	All	1179/1132 (104%)	1164 (99%)	15 (1%)	61	40

5 of 15 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	17	GLU
1	D	125	LYS
1	C	30	SER
1	D	227	LEU
1	C	195	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 18 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	301	ASN
1	D	302	GLN
1	D	301	ASN
1	B	233	HIS
1	C	233	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 19 ligands modelled in this entry, 4 are monoatomic - leaving 15 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
3	1PE	C	348	-	12,12,15	0.42	0	11,11,14	0.33	0
3	1PE	D	348	-	15,15,15	0.45	0	14,14,14	0.42	0
4	PEG	D	350	-	6,6,6	0.45	0	5,5,5	0.25	0
3	1PE	A	347	-	15,15,15	0.45	0	14,14,14	0.31	0
3	1PE	A	348	-	15,15,15	0.34	0	14,14,14	0.70	0
4	PEG	B	349	-	6,6,6	0.43	0	5,5,5	0.34	0
3	1PE	B	348	-	12,12,15	0.43	0	11,11,14	0.29	0
3	1PE	B	347	-	15,15,15	0.38	0	14,14,14	0.49	0
4	PEG	A	350	-	6,6,6	0.49	0	5,5,5	0.22	0
3	1PE	C	349	-	9,9,15	0.43	0	8,8,14	0.45	0
3	1PE	D	349	-	15,15,15	0.44	0	14,14,14	0.33	0
4	PEG	A	351	-	6,6,6	0.47	0	5,5,5	0.37	0
3	1PE	D	347	-	15,15,15	0.47	0	14,14,14	0.32	0
3	1PE	C	347	-	15,15,15	0.43	0	14,14,14	0.34	0
3	1PE	A	349	-	12,12,15	0.48	0	11,11,14	0.16	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
3	1PE	C	348	-	-	6/10/10/13	-
3	1PE	D	348	-	-	8/13/13/13	-
4	PEG	D	350	-	-	2/4/4/4	-
3	1PE	A	347	-	-	6/13/13/13	-
3	1PE	A	348	-	-	0/13/13/13	-
4	PEG	B	349	-	-	4/4/4/4	-
3	1PE	B	348	-	-	7/10/10/13	-
3	1PE	B	347	-	-	7/13/13/13	-
4	PEG	A	350	-	-	3/4/4/4	-
3	1PE	C	349	-	-	4/7/7/13	-
3	1PE	D	349	-	-	5/13/13/13	-
4	PEG	A	351	-	-	3/4/4/4	-
3	1PE	D	347	-	-	4/13/13/13	-
3	1PE	C	347	-	-	4/13/13/13	-
3	1PE	A	349	-	-	5/10/10/13	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

5 of 68 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	C	348	1PE	OH4-C13-C23-OH3
3	B	347	1PE	OH4-C13-C23-OH3
3	C	349	1PE	OH2-C12-C22-OH3
3	D	348	1PE	OH4-C13-C23-OH3
3	D	348	1PE	OH2-C12-C22-OH3

There are no ring outliers.

7 monomers are involved in 26 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	C	348	1PE	2	0
3	D	348	1PE	9	0
3	B	348	1PE	2	0
3	C	349	1PE	4	0
3	D	349	1PE	1	0
4	A	351	PEG	4	0
3	A	349	1PE	4	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, 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	336/345 (97%)	-1.12	0 100 100	9, 18, 32, 46	6 (1%)
1	B	336/345 (97%)	-1.14	0 100 100	9, 17, 33, 43	8 (2%)
1	C	336/345 (97%)	-1.15	0 100 100	10, 18, 34, 43	5 (1%)
1	D	336/345 (97%)	-1.13	0 100 100	10, 18, 33, 44	4 (1%)
All	All	1344/1380 (97%)	-1.13	0 100 100	9, 18, 33, 46	23 (1%)

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 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(Å ²)	Q<0.9
3	1PE	D	347	16/16	0.96	0.08	38,43,51,52	0
3	1PE	C	348	13/16	0.97	0.07	40,41,47,49	0
3	1PE	B	348	13/16	0.97	0.06	41,42,45,46	0
3	1PE	D	348	16/16	0.97	0.07	42,45,47,47	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	1PE	D	349	16/16	0.97	0.07	39,40,47,49	0
4	PEG	A	351	7/7	0.97	0.07	39,39,41,42	0
3	1PE	A	347	16/16	0.98	0.06	40,43,46,47	0
3	1PE	C	347	16/16	0.98	0.06	29,33,40,41	0
3	1PE	A	349	13/16	0.98	0.06	44,45,48,49	0
3	1PE	C	349	10/16	0.98	0.07	39,44,45,45	0
4	PEG	B	349	7/7	0.98	0.07	48,49,50,50	0
4	PEG	D	350	7/7	0.98	0.06	46,46,47,47	0
2	MN	D	346	1/1	0.99	0.16	15,15,15,15	0
2	MN	B	346	1/1	0.99	0.18	17,17,17,17	0
4	PEG	A	350	7/7	0.99	0.05	41,41,44,45	0
3	1PE	A	348	16/16	0.99	0.04	19,21,28,32	0
2	MN	C	346	1/1	0.99	0.16	16,16,16,16	0
3	1PE	B	347	16/16	0.99	0.04	32,37,39,40	0
2	MN	A	346	1/1	1.00	0.14	15,15,15,15	0

6.5 Other polymers [i](#)

There are no such residues in this entry.