



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 02:57 AM UTC

PDB ID : 5BNC / pdb_00005bnc
Title : Structure of heme binding protein MSMEG_6519 from Mycobacterium smegmatis
Authors : Ahmed, F.H.; Carr, P.D.; Jackson, C.J.
Deposited on : 2015-05-26
Resolution : 2.25 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

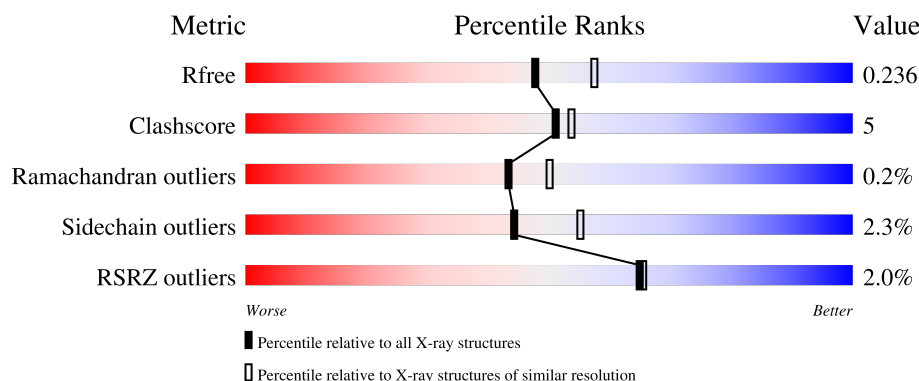
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.25 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	1898 (2.26-2.26)
Clashscore	190562	2005 (2.26-2.26)
Ramachandran outliers	187476	1965 (2.26-2.26)
Sidechain outliers	187428	1966 (2.26-2.26)
RSRZ outliers	180081	1898 (2.26-2.26)

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	252	
1	B	252	

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	EPE	A	302	-	-	X	-
3	EPE	A	304	-	-	X	-

2 Entry composition [i](#)

There are 6 unique types of molecules in this entry. The entry contains 3989 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.

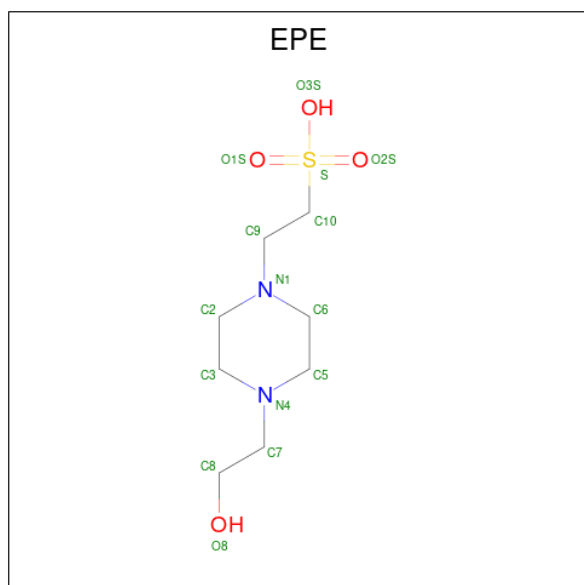
- Molecule 1 is a protein called heme binding protein MSMEG_6519.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	252	Total	C	N	O	S	0	3	0
			1859	1158	332	364	5			
1	B	242	Total	C	N	O	S	0	5	0
			1812	1125	327	354	6			

- Molecule 2 is NICKEL (II) ION (CCD ID: NI) (formula: Ni).

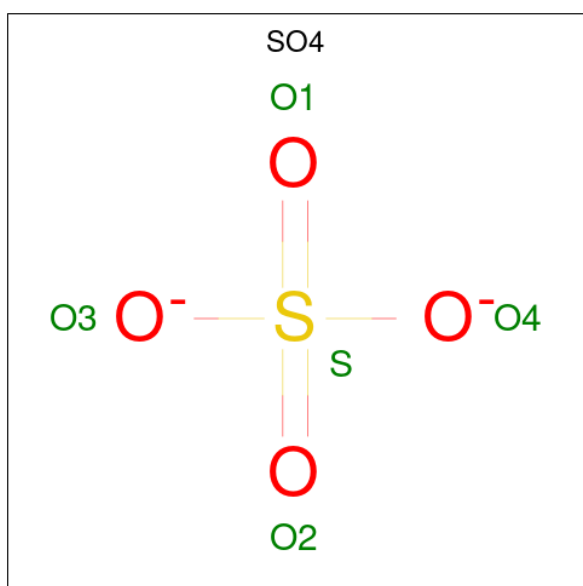
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Ni	0	0
			1	1		
2	B	1	Total	Ni	0	0
			1	1		

- Molecule 3 is 4-(2-HYDROXYETHYL)-1-PIPERAZINE ETHANESULFONIC ACID (CCD ID: EPE) (formula: C₈H₁₈N₂O₄S).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total	C	N	O	S	0	0
			15	8	2	4	1		
3	A	1	Total	C	N	O	S	0	0
			15	8	2	4	1		
3	A	1	Total	C	N	O	S	0	0
			15	8	2	4	1		
3	B	1	Total	C	N	O	S	0	0
			15	8	2	4	1		

- Molecule 4 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	B	1	Total	O	S	0	0
			5	4	1		

- Molecule 5 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	B	1	Total	Mg	0	0
			1	1		

- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	116	Total	O	0	0
			116	116		

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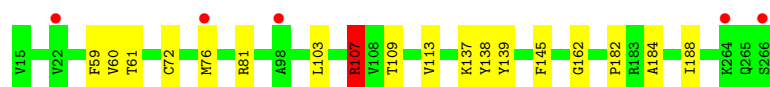
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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	B	134	Total 134	O 134	0	0

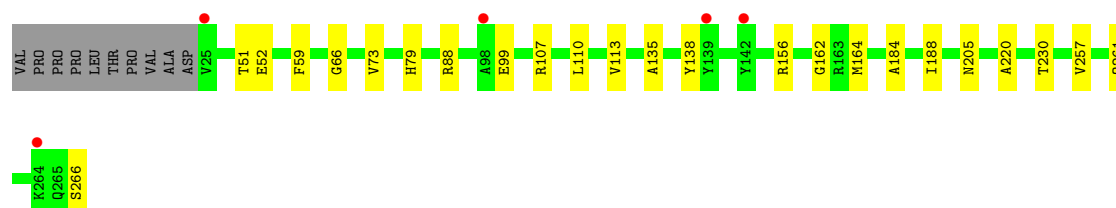
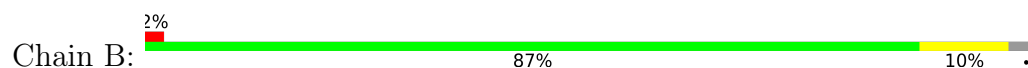
3 Residue-property plots [i](#)

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: heme binding protein MSMEG_6519



- Molecule 1: heme binding protein MSMEG_6519



4 Data and refinement statistics

Property	Value	Source
Space group	P 61	Depositor
Cell constants a, b, c, α , β , γ	62.10Å 62.10Å 301.41Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	43.77 – 2.25 43.77 – 2.25	Depositor EDS
% Data completeness (in resolution range)	99.9 (43.77-2.25) 99.9 (43.77-2.25)	Depositor EDS
R_{merge}	0.10	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.51 (at 2.24Å)	Xtriage
Refinement program	REFMAC 5.8.0049	Depositor
R, R_{free}	0.185 , 0.230 0.190 , 0.236	Depositor DCC
R_{free} test set	1588 reflections (5.12%)	wwPDB-VP
Wilson B-factor (Å ²)	30.0	Xtriage
Anisotropy	0.045	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 34.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.42$, $\langle L^2 \rangle = 0.25$	Xtriage
Estimated twinning fraction	0.124 for h,-h-k,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	3989	wwPDB-VP
Average B, all atoms (Å ²)	33.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.77% 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: EPE, NI, SO4, MG

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	0.97	0/1906	0.96	1/2610 (0.0%)
1	B	0.96	0/1858	0.97	2/2536 (0.1%)
All	All	0.97	0/3764	0.96	3/5146 (0.1%)

There are no bond length outliers.

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	107	ARG	NE-CZ-NH2	7.07	125.56	119.20
1	B	162	GLY	N-CA-C	5.14	122.27	114.61
1	B	51	THR	CB-CA-C	-5.00	101.07	110.67

There are no chirality outliers.

There are no planarity outliers.

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	1859	0	1820	22	0
1	B	1812	0	1775	17	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
3	A	45	0	51	23	0
3	B	15	0	17	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	B	5	0	0	0	0
5	B	1	0	0	0	0
6	A	116	0	0	2	0
6	B	134	0	0	3	0
All	All	3989	0	3663	38	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 5.

All (38) 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:109:THR:OG1	3:A:304:EPE:O2S	1.72	1.06
3:A:302:EPE:O2S	1:B:107:ARG:HD2	1.70	0.92
1:A:107:ARG:HE	3:A:304:EPE:H22	1.36	0.91
1:A:107:ARG:HE	3:A:304:EPE:C2	1.85	0.90
1:A:72:CYS:O	3:A:302:EPE:H72	1.75	0.86
1:A:59:PHE:O	3:A:302:EPE:H102	1.81	0.79
1:B:184:ALA:O	1:B:188:ILE:HG12	1.89	0.72
1:A:184:ALA:O	1:A:188:ILE:HG12	1.93	0.69
1:A:107:ARG:HH11	3:A:304:EPE:H32	1.60	0.66
1:A:107:ARG:NE	3:A:304:EPE:H22	2.12	0.62
1:A:182:PRO:HG2	6:A:432:HOH:O	1.99	0.62
1:A:60:VAL:HG12	3:A:302:EPE:H21	1.82	0.62
1:A:107:ARG:HE	3:A:304:EPE:H21	1.64	0.61
3:A:304:EPE:H91	1:B:59:PHE:HB3	1.86	0.58
1:A:76:MET:HG2	6:A:500:HOH:O	2.04	0.57
1:A:109:THR:CB	3:A:304:EPE:O2S	2.51	0.56
1:A:107:ARG:HH11	3:A:304:EPE:C3	2.23	0.52
1:B:205:ASN:HB3	1:B:266:SER:HB2	1.93	0.50
1:A:61:THR:OG1	3:A:302:EPE:H51	2.12	0.50
1:A:103:LEU:HD23	1:B:135:ALA:HB3	1.95	0.48
1:A:59:PHE:O	3:A:302:EPE:C10	2.58	0.46
3:A:304:EPE:H72	1:B:59:PHE:O	2.16	0.46
3:A:304:EPE:H51	1:B:79:HIS:HE1	1.81	0.46
1:B:188:ILE:HD11	1:B:220:ALA:N	2.31	0.46
1:A:59:PHE:O	3:A:302:EPE:H91	2.16	0.45
1:A:60:VAL:HA	3:A:302:EPE:H62	1.99	0.45
1:A:60:VAL:HA	3:A:302:EPE:H21	1.98	0.45
1:B:156:ARG:NH2	1:B:164:MET:HG3	2.33	0.44
1:B:66:GLY:O	6:B:401:HOH:O	2.21	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:137:LYS:HE3	1:A:138:TYR:CE1	2.53	0.43
1:B:257:VAL:O	1:B:261[B]:GLN:HG3	2.19	0.43
1:B:88:ARG:NH1	6:B:410:HOH:O	2.50	0.42
3:A:304:EPE:H51	1:B:79:HIS:CE1	2.55	0.41
3:A:302:EPE:O2S	1:B:107:ARG:CD	2.55	0.41
1:B:73:VAL:HG13	1:B:79:HIS:NE2	2.35	0.41
3:A:304:EPE:C5	1:B:79:HIS:CE1	3.03	0.41
1:A:139:TYR:HD2	1:A:145:PHE:CZ	2.38	0.41
1:B:230:THR:HG21	6:B:515:HOH:O	2.22	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	253/252 (100%)	247 (98%)	5 (2%)	1 (0%)	30	31
1	B	245/252 (97%)	241 (98%)	4 (2%)	0	100	100
All	All	498/504 (99%)	488 (98%)	9 (2%)	1 (0%)	43	50

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	162	GLY

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	184/182 (101%)	180 (98%)	4 (2%)	45	56
1	B	178/182 (98%)	172 (97%)	6 (3%)	32	40
All	All	362/364 (100%)	352 (97%)	10 (3%)	44	48

All (10) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	81[A]	ARG
1	A	81[B]	ARG
1	A	107	ARG
1	A	113	VAL
1	B	52[A]	GLU
1	B	52[B]	GLU
1	B	99	GLU
1	B	110	LEU
1	B	113	VAL
1	B	138	TYR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	153	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 oligosaccharides in this entry.

5.6 Ligand geometry

Of 8 ligands modelled in this entry, 3 are monoatomic - leaving 5 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	EPE	A	304	-	15,15,15	1.86	3 (20%)	19,20,20	2.65	9 (47%)
3	EPE	A	302	-	15,15,15	2.30	4 (26%)	19,20,20	3.42	8 (42%)
4	SO4	B	303	-	4,4,4	0.66	0	6,6,6	0.21	0
3	EPE	B	301	-	15,15,15	1.81	1 (6%)	19,20,20	1.85	4 (21%)
3	EPE	A	303	-	15,15,15	1.61	1 (6%)	19,20,20	2.03	6 (31%)

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	EPE	B	301	-	-	2/9/19/19	0/1/1/1
3	EPE	A	302	-	-	4/9/19/19	0/1/1/1
3	EPE	A	303	-	-	4/9/19/19	0/1/1/1
3	EPE	A	304	-	-	3/9/19/19	0/1/1/1

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	302	EPE	C10-S	-7.43	1.67	1.77
3	B	301	EPE	C10-S	-6.20	1.68	1.77
3	A	304	EPE	C10-S	-5.81	1.69	1.77
3	A	303	EPE	C10-S	-5.48	1.69	1.77
3	A	304	EPE	C7-N4	2.65	1.53	1.47
3	A	302	EPE	C3-N4	2.52	1.53	1.46
3	A	302	EPE	O1S-S	2.20	1.51	1.45
3	A	304	EPE	O1S-S	2.10	1.51	1.45
3	A	302	EPE	C7-N4	2.02	1.52	1.47

All (27) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	302	EPE	O2S-S-C10	9.63	121.28	106.73
3	A	302	EPE	O1S-S-C10	-7.78	94.97	106.73
3	A	304	EPE	O1S-S-C10	6.67	116.81	106.73
3	B	301	EPE	O1S-S-C10	5.58	115.16	106.73
3	A	303	EPE	O2S-S-C10	5.54	115.09	106.73
3	A	304	EPE	O2S-S-O1S	-4.98	97.62	113.82
3	A	302	EPE	C5-N4-C3	3.35	116.05	108.84
3	A	304	EPE	C3-C2-N1	3.10	116.90	110.65
3	A	304	EPE	O2S-S-C10	3.08	111.39	106.73
3	A	302	EPE	C5-C6-N1	-3.05	104.50	110.65
3	A	303	EPE	C3-C2-N1	2.97	116.63	110.65
3	A	302	EPE	C9-N1-C6	-2.82	103.73	111.24
3	A	302	EPE	C8-C7-N4	2.78	123.18	113.44
3	A	303	EPE	C6-C5-N4	-2.75	105.11	110.65
3	A	303	EPE	O3S-S-O1S	-2.71	104.63	111.40
3	A	304	EPE	C5-N4-C3	-2.68	103.07	108.84
3	A	304	EPE	C9-N1-C6	2.67	118.35	111.24
3	A	302	EPE	O3S-S-O1S	2.57	117.82	111.40
3	A	302	EPE	C9-N1-C2	2.56	118.05	111.24
3	A	303	EPE	O1S-S-C10	2.44	110.41	106.73
3	A	304	EPE	C6-C5-N4	2.43	115.56	110.65
3	A	304	EPE	C6-N1-C2	-2.38	103.71	108.84
3	A	303	EPE	O3S-S-C10	2.34	110.59	106.00
3	B	301	EPE	C6-C5-N4	2.32	115.33	110.65
3	B	301	EPE	C9-N1-C6	2.16	117.00	111.24
3	A	304	EPE	C7-N4-C5	2.15	116.98	111.24
3	B	301	EPE	O2S-S-C10	2.10	109.90	106.73

There are no chirality outliers.

All (13) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	302	EPE	C10-C9-N1-C2
3	A	302	EPE	C8-C7-N4-C5
3	A	304	EPE	C10-C9-N1-C6
3	B	301	EPE	C10-C9-N1-C6
3	B	301	EPE	N4-C7-C8-O8
3	A	303	EPE	C9-C10-S-O3S
3	A	304	EPE	S-C10-C9-N1
3	A	304	EPE	N4-C7-C8-O8
3	A	303	EPE	C9-C10-S-O1S

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Mol	Chain	Res	Type	Atoms
3	A	303	EPE	C9-C10-S-O2S
3	A	302	EPE	S-C10-C9-N1
3	A	303	EPE	N4-C7-C8-O8
3	A	302	EPE	C8-C7-N4-C3

There are no ring outliers.

2 monomers are involved in 23 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	304	EPE	13	0
3	A	302	EPE	10	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, 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	252/252 (100%)	-0.34	5 (1%) 65 65	17, 30, 51, 80	3 (1%)
1	B	242/252 (96%)	-0.23	5 (2%) 63 64	15, 30, 56, 74	5 (2%)
All	All	494/504 (98%)	-0.29	10 (2%) 65 65	15, 30, 55, 80	8 (1%)

All (10) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	142	TYR	3.3
1	A	266	SER	3.0
1	B	98	ALA	2.9
1	A	98	ALA	2.6
1	B	264	LYS	2.4
1	A	22	VAL	2.4
1	A	264	LYS	2.3
1	A	76	MET	2.1
1	B	25	VAL	2.1
1	B	139	TYR	2.1

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 ⓘ

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
4	SO4	B	303	5/5	0.78	0.13	69,70,81,88	0
3	EPE	A	304	15/15	0.79	0.25	33,39,45,46	15
3	EPE	A	302	15/15	0.80	0.22	22,30,37,38	15
5	MG	B	304	1/1	0.81	0.22	61,61,61,61	0
3	EPE	A	303	15/15	0.89	0.17	41,55,66,72	15
3	EPE	B	301	15/15	0.95	0.10	35,41,43,44	15
2	NI	A	301	1/1	0.99	0.02	26,26,26,26	0
2	NI	B	302	1/1	1.00	0.01	28,28,28,28	0

6.5 Other polymers [i](#)

There are no such residues in this entry.