



# Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 03:05 AM UTC

PDB ID : 9IAB / pdb\_00009iab  
Title : Structure of the Argonaute-associated Cas4 family protein 1 (ACE1) from  
Chroococcidiopsis thermalis (CtACE1)  
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Deposited on : 2025-02-09  
Resolution : 1.57 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

<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>.

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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

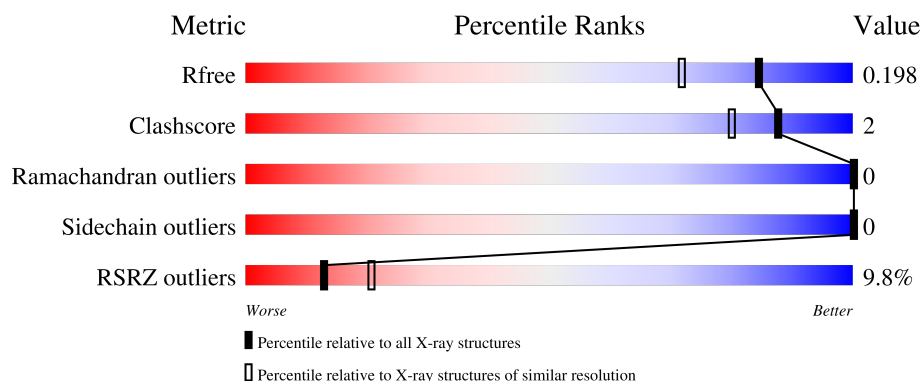
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 1.57 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	1094 (1.58-1.58)
Clashscore	190562	1105 (1.58-1.58)
Ramachandran outliers	187476	1082 (1.58-1.58)
Sidechain outliers	187428	1081 (1.58-1.58)
RSRZ outliers	180081	1094 (1.58-1.58)

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  $\geq 3$ , 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	273	<div> <div>9%</div> <div>93%</div> <div>• •</div> </div>
1	B	273	<div> <div>10%</div> <div>93%</div> <div>• •</div> </div>

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
4	SO4	B	304	-	-	X	-

## 2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 9217 atoms, of which 4377 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.

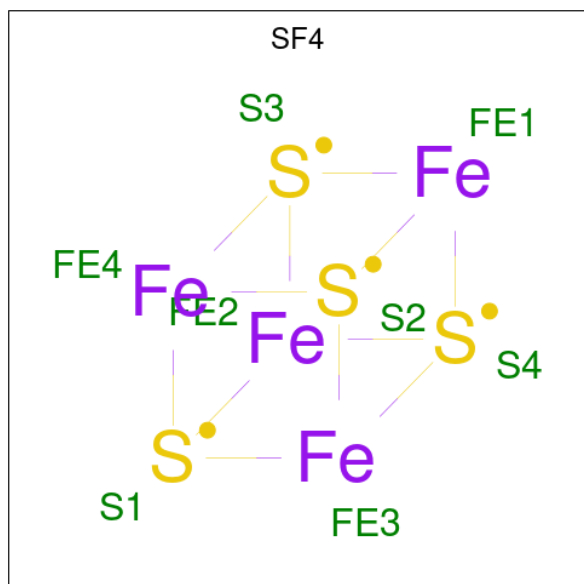
- Molecule 1 is a protein called PD-(D/E)XK endonuclease-like domain-containing protein.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	266	Total	C	H	N	O	S	0	4	0
			4304	1377	2142	376	400	9			
1	B	266	Total	C	H	N	O	S	0	9	0
			4377	1397	2183	386	402	9			

There are 4 discrepancies between the modelled and reference sequences:

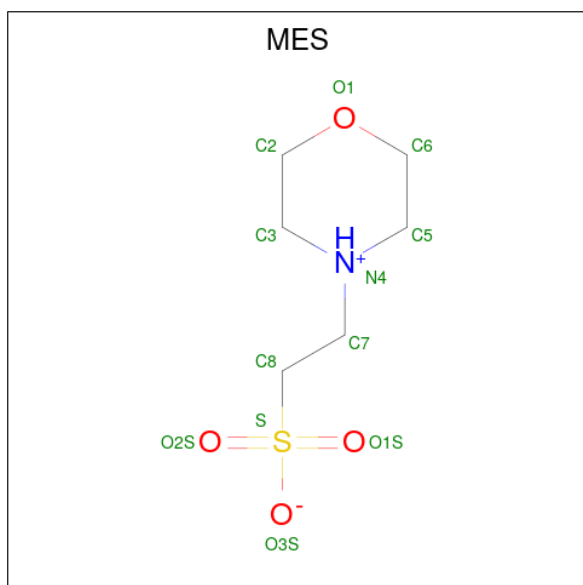
Chain	Residue	Modelled	Actual	Comment	Reference
A	0	SER	-	expression tag	UNP K9U6V4
A	1	ALA	-	expression tag	UNP K9U6V4
B	0	SER	-	expression tag	UNP K9U6V4
B	1	ALA	-	expression tag	UNP K9U6V4

- Molecule 2 is IRON/SULFUR CLUSTER (CCD ID: SF4) (formula: Fe<sub>4</sub>S<sub>4</sub>).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	Fe	S	0	0
			8	4	4		
2	B	1	Total	Fe	S	0	0
			8	4	4		

- Molecule 3 is 2-(N-MORPHOLINO)-ETHANESULFONIC ACID (CCD ID: MES) (formula:  $C_6H_{13}NO_4S$ ).



Mol	Chain	Residues	Atoms						ZeroOcc	AltConf
3	A	1	Total 25	C 6	H 13	N 1	O 4	S 1	0	0
3	A	1	Total 25	C 6	H 13	N 1	O 4	S 1	0	0
3	B	1	Total 25	C 6	H 13	N 1	O 4	S 1	0	0
3	B	1	Total 25	C 6	H 13	N 1	O 4	S 1	0	0

- Molecule 4 is SULFATE ION (CCD ID: SO4) (formula:  $O_4S$ ).



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

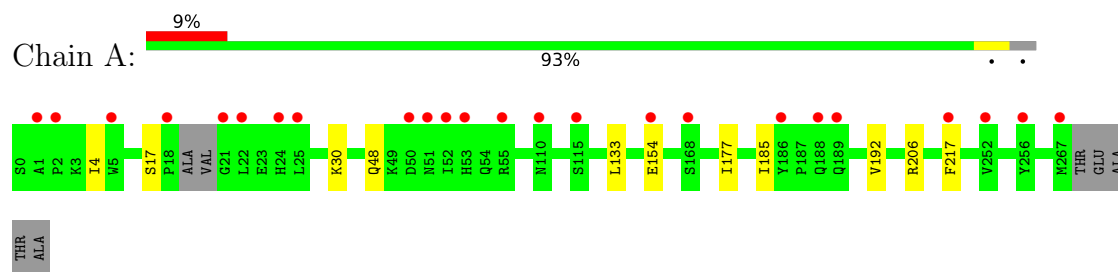
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	221	Total	O	0	0
			221	221		
5	B	174	Total	O	0	0
			174	174		

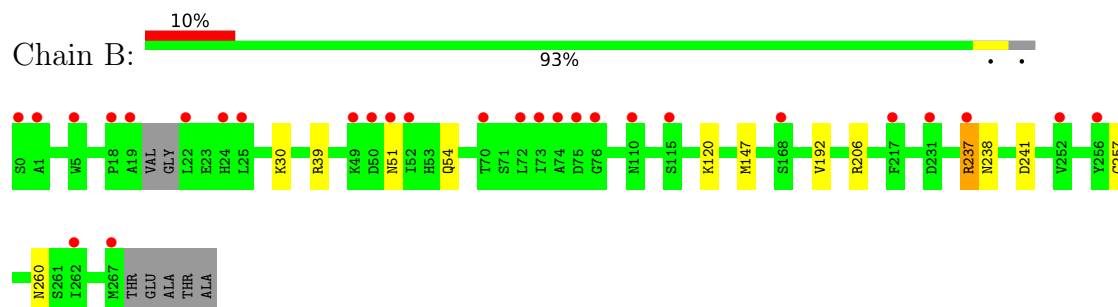
### 3 Residue-property plots

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: PD-(D/E)XK endonuclease-like domain-containing protein



- Molecule 1: PD-(D/E)XK endonuclease-like domain-containing protein



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	44.91Å 44.95Å 74.06Å 100.17° 92.22° 105.87°	Depositor
Resolution (Å)	43.02 – 1.57 43.02 – 1.57	Depositor EDS
% Data completeness (in resolution range)	94.6 (43.02-1.57) 96.7 (43.02-1.57)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	3.51 (at 1.57Å)	Xtriage
Refinement program	PHENIX 1.20.1_4487	Depositor
R, $R_{free}$	0.186 , 0.199 0.186 , 0.198	Depositor DCC
$R_{free}$ test set	2000 reflections (2.62%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	25.2	Xtriage
Anisotropy	0.045	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.40 , 40.0	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.50$ , $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.97	EDS
Total number of atoms	9217	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	39.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 7.15% 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, 0.333 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: MES, SF4, SO4

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	0.44	1/2217 (0.0%)	0.61	0/2986
1	B	0.44	0/2267	0.67	0/3052
All	All	0.44	1/4484 (0.0%)	0.64	0/6038

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

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	17	SER	C-O	-5.03	1.20	1.25

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	237	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	2162	2142	2141	8	0
1	B	2194	2183	2164	10	0
2	A	8	0	0	0	0
2	B	8	0	0	0	0
3	A	24	26	25	0	0
3	B	24	26	24	0	0
4	A	20	0	0	0	0
4	B	5	0	0	2	0
5	A	221	0	0	2	0
5	B	174	0	0	2	0
All	All	4840	4377	4354	18	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 2.

All (18) 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:B:237:ARG:NH1	5:B:401:HOH:O	2.20	0.74
1:B:39[B]:ARG:NH1	5:B:402:HOH:O	2.28	0.66
1:B:39[B]:ARG:CZ	4:B:304:SO4:O3	2.51	0.58
1:A:48:GLN:HG3	1:A:48:GLN:O	2.03	0.58
1:B:51:ASN:HB3	1:B:54:GLN:HG3	1.87	0.57
1:B:120:LYS:HE3	1:B:147:MET:O	2.05	0.56
1:A:192:VAL:HG21	1:A:206:ARG:HB3	1.92	0.50
1:A:185:ILE:HD11	5:A:496:HOH:O	2.11	0.49
1:A:154:GLU:CD	1:A:154:GLU:H	2.22	0.48
1:A:177:ILE:CG1	1:A:217:PHE:HE2	2.27	0.47
1:B:192:VAL:HG21	1:B:206:ARG:HB3	1.97	0.45
1:A:30:LYS:NZ	5:A:405:HOH:O	2.39	0.44
1:B:30:LYS:HE2	1:B:257:CYS:SG	2.57	0.44
1:B:39[B]:ARG:NH2	4:B:304:SO4:O3	2.50	0.44
1:A:4:ILE:HD13	1:A:133:LEU:HD12	1.99	0.44
1:B:238:ASN:HD22	1:B:241:ASP:CG	2.27	0.42
1:A:177:ILE:HG12	1:A:217:PHE:HE2	1.85	0.40
1:B:257:CYS:HB3	1:B:260:ASN:OD1	2.22	0.40

There are no symmetry-related clashes.

## 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	266/273 (97%)	264 (99%)	2 (1%)	0	100	100
1	B	271/273 (99%)	267 (98%)	4 (2%)	0	100	100
All	All	537/546 (98%)	531 (99%)	6 (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	234/239 (98%)	234 (100%)	0	100	100
1	B	239/239 (100%)	239 (100%)	0	100	100
All	All	473/478 (99%)	473 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	102	GLN
1	A	229	GLN
1	B	11	ASN
1	B	102	GLN
1	B	238	ASN

### 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 ⓘ

11 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	SF4	A	301	1	0,12,12	-	-	-		
4	SO4	A	305	-	4,4,4	0.24	0	6,6,6	0.09	0
4	SO4	A	307	-	4,4,4	0.22	0	6,6,6	0.19	0
3	MES	A	303	-	12,12,12	2.19	1 (8%)	15,16,16	1.60	3 (20%)
4	SO4	B	304	-	4,4,4	0.41	0	6,6,6	0.08	0
3	MES	B	303	-	12,12,12	2.30	1 (8%)	15,16,16	2.05	5 (33%)
2	SF4	B	301	1	0,12,12	-	-	-		
4	SO4	A	306	-	4,4,4	0.23	0	6,6,6	0.13	0
4	SO4	A	304	-	4,4,4	0.25	0	6,6,6	0.16	0
3	MES	A	302	-	12,12,12	2.21	1 (8%)	15,16,16	1.81	4 (26%)
3	MES	B	302	-	12,12,12	2.12	1 (8%)	15,16,16	2.21	5 (33%)

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	SF4	A	301	1	-	-	0/6/5/5
3	MES	A	303	-	-	4/6/14/14	0/1/1/1
3	MES	B	303	-	-	3/6/14/14	0/1/1/1
2	SF4	B	301	1	-	-	0/6/5/5
3	MES	A	302	-	-	2/6/14/14	0/1/1/1
3	MES	B	302	-	-	3/6/14/14	0/1/1/1

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	B	303	MES	C8-S	-7.68	1.66	1.77
3	A	302	MES	C8-S	-7.36	1.67	1.77
3	A	303	MES	C8-S	-7.29	1.67	1.77
3	B	302	MES	C8-S	-7.06	1.67	1.77

All (17) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	303	MES	C6-C5-N4	-4.54	103.21	110.12
3	B	302	MES	C6-C5-N4	-4.30	103.58	110.12
3	B	302	MES	O2S-S-C8	4.27	113.19	106.73
3	A	302	MES	C6-C5-N4	-3.40	104.95	110.12
3	B	302	MES	C5-N4-C3	3.38	116.12	108.84
3	A	302	MES	O2S-S-C8	3.37	111.81	106.73
3	A	302	MES	C5-N4-C3	3.34	116.03	108.84
3	A	303	MES	C5-N4-C3	3.28	115.90	108.84
3	B	303	MES	O1S-S-C8	3.25	111.63	106.73
3	B	302	MES	O1S-S-C8	3.16	111.51	106.73
3	B	303	MES	C5-N4-C3	3.08	115.47	108.84
3	A	303	MES	C6-C5-N4	-2.71	106.00	110.12
3	A	303	MES	O1S-S-C8	2.65	110.73	106.73
3	B	303	MES	O2S-S-C8	2.59	110.65	106.73
3	B	303	MES	C7-N4-C5	2.56	118.05	111.24
3	A	302	MES	C7-N4-C5	2.34	117.47	111.24
3	B	302	MES	O2S-S-O1S	-2.12	106.93	113.82

There are no chirality outliers.

All (12) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	303	MES	C8-C7-N4-C3

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Mol	Chain	Res	Type	Atoms
3	B	302	MES	C7-C8-S-O1S
3	B	302	MES	C7-C8-S-O3S
3	B	303	MES	C7-C8-S-O2S
3	B	303	MES	C7-C8-S-O3S
3	A	303	MES	C8-C7-N4-C5
3	A	302	MES	C7-C8-S-O2S
3	A	303	MES	C7-C8-S-O2S
3	B	302	MES	C7-C8-S-O2S
3	B	303	MES	C7-C8-S-O1S
3	A	302	MES	C7-C8-S-O3S
3	A	303	MES	C7-C8-S-O3S

There are no ring outliers.

1 monomer is involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	B	304	SO4	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<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	266/273 (97%)	0.54	24 (9%)	15 23	15, 34, 73, 99	4 (1%)
1	B	266/273 (97%)	0.59	28 (10%)	11 18	14, 36, 74, 108	7 (2%)
All	All	532/546 (97%)	0.56	52 (9%)	13 21	14, 35, 74, 108	11 (2%)

All (52) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	256	TYR	4.8
1	B	22	LEU	4.8
1	A	256	TYR	4.7
1	B	73	ILE	4.4
1	A	52	ILE	4.1
1	A	53	HIS	3.9
1	B	72	LEU	3.7
1	A	22	LEU	3.7
1	A	51	ASN	3.6
1	A	50	ASP	3.5
1	B	75	ASP	3.5
1	A	21	GLY	3.4
1	A	252	VAL	3.3
1	B	252	VAL	3.2
1	A	18	PRO	2.9
1	A	115	SER	2.8
1	B	24	HIS	2.8
1	B	1	ALA	2.7
1	B	25	LEU	2.7
1	B	5	TRP	2.7
1	A	267	MET	2.7
1	B	49	LYS	2.6
1	A	5	TRP	2.6
1	A	1	ALA	2.6

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Mol	Chain	Res	Type	RSRZ
1	B	115	SER	2.6
1	B	267	MET	2.5
1	A	217	PHE	2.5
1	B	50	ASP	2.4
1	B	19	ALA	2.4
1	B	52	ILE	2.4
1	B	110	ASN	2.4
1	A	55	ARG	2.4
1	A	2	PRO	2.3
1	B	51	ASN	2.3
1	B	76	GLY	2.3
1	A	188	GLN	2.3
1	B	168	SER	2.3
1	A	168	SER	2.3
1	A	24	HIS	2.2
1	A	186	TYR	2.2
1	B	74	ALA	2.2
1	B	70	THR	2.2
1	B	237	ARG	2.2
1	B	18	PRO	2.1
1	B	262	ILE	2.1
1	B	0	SER	2.1
1	A	189	GLN	2.1
1	A	25	LEU	2.1
1	A	154	GLU	2.1
1	A	110	ASN	2.0
1	B	231	ASP	2.0
1	B	217	PHE	2.0

## 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, 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	B-factors(Å <sup>2</sup> )	Q<0.9
4	SO4	A	305	5/5	0.61	0.11	95,96,105,107	0
3	MES	B	303	12/12	0.73	0.16	52,68,87,87	0
3	MES	A	303	12/12	0.76	0.16	44,62,80,83	0
4	SO4	B	304	5/5	0.78	0.13	81,82,83,84	0
4	SO4	A	306	5/5	0.80	0.18	85,85,88,92	0
4	SO4	A	304	5/5	0.83	0.12	57,58,72,76	0
4	SO4	A	307	5/5	0.85	0.15	70,77,79,131	0
3	MES	B	302	12/12	0.89	0.12	43,52,59,62	0
3	MES	A	302	12/12	0.91	0.10	41,50,56,59	0
2	SF4	B	301	8/8	0.99	0.03	30,32,34,34	0
2	SF4	A	301	8/8	0.99	0.04	28,32,35,36	0

## 6.5 Other polymers [i](#)

There are no such residues in this entry.