



# Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 11:24 PM UTC

PDB ID : 7VX2 / pdb\_00007vx2  
Title : Crystal Structure of the Y53F/N55A/I80F/L114V/I116V mutant of LEH  
Authors : Qu, G.; Li, X.; Sun, Z.T.; Han, X.; Liu, W.D.  
Deposited on : 2021-11-12  
Resolution : 2.48 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>.

---

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)  
Xtrriage (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

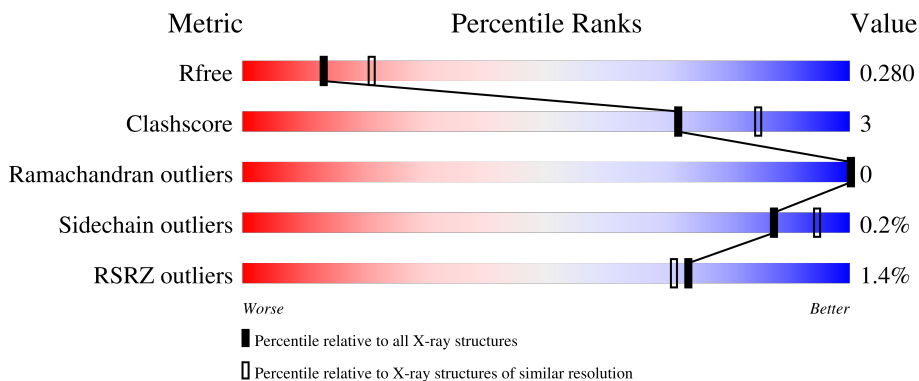
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 2.48 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	7589 (2.50-2.46)
Clashscore	190562	8295 (2.50-2.46)
Ramachandran outliers	187476	8164 (2.50-2.46)
Sidechain outliers	187428	8166 (2.50-2.46)
RSRZ outliers	180081	7593 (2.50-2.46)

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	155	 84% 9% 7%
1	B	155	 88% 5% 7%
1	C	155	 94% . .
1	D	155	 95% . . .

## 2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 9206 atoms, of which 4497 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 Limonene-1,2-epoxide hydrolase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	H	N	O	S			
1	A	144	2214	719	1089	181	221	4	0	0	0
1	B	144	2214	719	1089	181	221	4	0	0	0
1	C	152	2352	764	1153	198	232	5	0	2	0
1	D	151	2317	752	1136	195	230	4	0	0	0

There are 48 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-5	MET	-	initiating methionine	UNP Q9ZAG3
A	-4	HIS	-	expression tag	UNP Q9ZAG3
A	-3	HIS	-	expression tag	UNP Q9ZAG3
A	-2	HIS	-	expression tag	UNP Q9ZAG3
A	-1	HIS	-	expression tag	UNP Q9ZAG3
A	0	HIS	-	expression tag	UNP Q9ZAG3
A	1	HIS	-	expression tag	UNP Q9ZAG3
A	53	PHE	TYR	engineered mutation	UNP Q9ZAG3
A	55	ALA	ASN	engineered mutation	UNP Q9ZAG3
A	80	PHE	ILE	engineered mutation	UNP Q9ZAG3
A	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
A	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
B	-5	MET	-	initiating methionine	UNP Q9ZAG3
B	-4	HIS	-	expression tag	UNP Q9ZAG3
B	-3	HIS	-	expression tag	UNP Q9ZAG3
B	-2	HIS	-	expression tag	UNP Q9ZAG3
B	-1	HIS	-	expression tag	UNP Q9ZAG3
B	0	HIS	-	expression tag	UNP Q9ZAG3
B	1	HIS	-	expression tag	UNP Q9ZAG3
B	53	PHE	TYR	engineered mutation	UNP Q9ZAG3
B	55	ALA	ASN	engineered mutation	UNP Q9ZAG3

*Continued on next page...*

*Continued from previous page...*

Chain	Residue	Modelled	Actual	Comment	Reference
B	80	PHE	ILE	engineered mutation	UNP Q9ZAG3
B	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
B	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
C	-5	MET	-	initiating methionine	UNP Q9ZAG3
C	-4	HIS	-	expression tag	UNP Q9ZAG3
C	-3	HIS	-	expression tag	UNP Q9ZAG3
C	-2	HIS	-	expression tag	UNP Q9ZAG3
C	-1	HIS	-	expression tag	UNP Q9ZAG3
C	0	HIS	-	expression tag	UNP Q9ZAG3
C	1	HIS	-	expression tag	UNP Q9ZAG3
C	53	PHE	TYR	engineered mutation	UNP Q9ZAG3
C	55	ALA	ASN	engineered mutation	UNP Q9ZAG3
C	80	PHE	ILE	engineered mutation	UNP Q9ZAG3
C	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
C	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
D	-5	MET	-	initiating methionine	UNP Q9ZAG3
D	-4	HIS	-	expression tag	UNP Q9ZAG3
D	-3	HIS	-	expression tag	UNP Q9ZAG3
D	-2	HIS	-	expression tag	UNP Q9ZAG3
D	-1	HIS	-	expression tag	UNP Q9ZAG3
D	0	HIS	-	expression tag	UNP Q9ZAG3
D	1	HIS	-	expression tag	UNP Q9ZAG3
D	53	PHE	TYR	engineered mutation	UNP Q9ZAG3
D	55	ALA	ASN	engineered mutation	UNP Q9ZAG3
D	80	PHE	ILE	engineered mutation	UNP Q9ZAG3
D	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
D	116	VAL	ILE	engineered mutation	UNP Q9ZAG3

- Molecule 2 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>).



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

- Molecule 3 is GLYCEROL (CCD ID: GOL) (formula: C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf	
3	B	1	Total	C	H	O	0	0
			14	3	8	3		

- Molecule 4 is DI(HYDROXYETHYL)ETHER (CCD ID: PEG) (formula: C<sub>4</sub>H<sub>10</sub>O<sub>3</sub>).



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

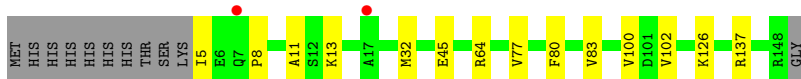
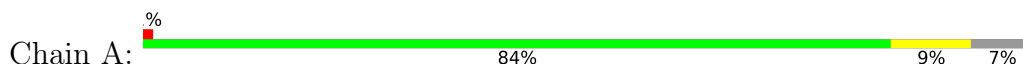
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	10	Total	O	0	0
			10	10		
5	B	18	Total	O	0	0
			18	18		
5	C	15	Total	O	0	0
			15	15		
5	D	15	Total	O	0	0
			15	15		

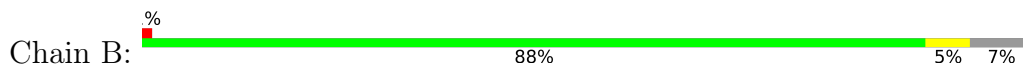
### 3 Residue-property plots [i](#)

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.

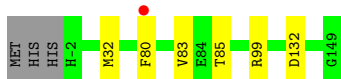
- Molecule 1: Limonene-1,2-epoxide hydrolase



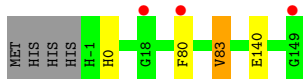
- Molecule 1: Limonene-1,2-epoxide hydrolase



- Molecule 1: Limonene-1,2-epoxide hydrolase



- Molecule 1: Limonene-1,2-epoxide hydrolase



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	74.15Å 84.04Å 93.37Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	27.80 – 2.48 27.80 – 2.48	Depositor EDS
% Data completeness (in resolution range)	94.7 (27.80-2.48) 94.6 (27.80-2.48)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	3.52 (at 2.47Å)	Xtrriage
Refinement program	PHENIX 1.11.1_2575	Depositor
R, $R_{free}$	0.231 , 0.277 0.233 , 0.280	Depositor DCC
$R_{free}$ test set	1040 reflections (4.91%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	24.0	Xtrriage
Anisotropy	0.719	Xtrriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.39 , 23.5	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.33$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
$F_o, F_c$ correlation	0.93	EDS
Total number of atoms	9206	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	29.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 46.46 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 1.1410e-04. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

<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 [i](#)

### 5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: GOL, 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	0.35	1/1150 (0.1%)	0.45	0/1563
1	B	0.36	0/1150	0.41	0/1563
1	C	0.18	0/1234	0.32	0/1675
1	D	0.34	2/1209 (0.2%)	0.37	0/1642
All	All	0.31	3/4743 (0.1%)	0.39	0/6443

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	D	83	VAL	C-O	-6.84	1.17	1.24
1	A	13	LYS	C-O	-5.40	1.16	1.23
1	D	0	HIS	C-O	-5.05	1.17	1.23

There are no bond angle outliers.

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	1125	1089	1089	12	0
1	B	1125	1089	1089	7	0
1	C	1199	1153	1162	7	0
1	D	1181	1136	1141	5	0

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	A	4	6	6	0	0
2	D	4	6	6	0	0
3	B	6	8	8	0	0
4	C	7	10	10	0	0
5	A	10	0	0	0	0
5	B	18	0	0	1	0
5	C	15	0	0	0	0
5	D	15	0	0	0	0
All	All	4709	4497	4511	30	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 3.

All (30) 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:80:PHE:HE1	1:C:83:VAL:HG13	1.42	0.83
1:C:80:PHE:HE1	1:C:83:VAL:CG1	1.96	0.78
1:A:80:PHE:HE2	1:A:83:VAL:CG2	2.01	0.73
1:D:80:PHE:HE1	1:D:83:VAL:CG1	2.01	0.72
1:B:92:ASN:ND2	5:B:301:HOH:O	2.32	0.62
1:A:80:PHE:CE2	1:A:83:VAL:CG2	2.86	0.57
1:C:80:PHE:CE1	1:C:83:VAL:CG1	2.83	0.56
1:C:80:PHE:CE1	1:C:83:VAL:HG13	2.31	0.56
1:D:83:VAL:O	1:D:83:VAL:HG23	2.05	0.55
1:A:80:PHE:HE2	1:A:83:VAL:HG21	1.71	0.54
1:C:32:MET:HA	1:C:32:MET:HE2	1.91	0.52
1:D:80:PHE:HE1	1:D:83:VAL:HG13	1.76	0.49
1:D:80:PHE:CE1	1:D:83:VAL:CG1	2.91	0.49
1:A:45:GLU:O	1:A:126:LYS:NZ	2.45	0.49
1:A:137:ARG:NH2	1:D:140:GLU:OE1	2.44	0.49
1:B:5:ILE:HG22	1:B:5:ILE:O	2.12	0.48
1:B:99:ARG:HH22	1:B:132:ASP:CG	2.23	0.47
1:B:80:PHE:HE2	1:B:83:VAL:CG2	2.28	0.46
1:A:80:PHE:CE2	1:A:83:VAL:HG22	2.50	0.45
1:A:5:ILE:HD11	1:A:102:VAL:HG23	1.98	0.44
1:C:99:ARG:NH2	1:C:132:ASP:OD2	2.42	0.44
1:B:72:ALA:O	1:B:76:THR:HG23	2.18	0.43
1:C:85:THR:HA	1:C:99:ARG:HB3	2.01	0.43
1:A:32:MET:HG2	1:A:83:VAL:HG11	2.00	0.42
1:A:45:GLU:HA	1:A:64:ARG:NH2	2.35	0.42

*Continued on next page...*

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:5:ILE:HD11	1:A:102:VAL:CG2	2.49	0.41
1:A:5:ILE:CG2	1:A:100:VAL:HG11	2.50	0.41
1:B:5:ILE:O	1:B:5:ILE:CG2	2.68	0.41
1:B:80:PHE:CE2	1:B:83:VAL:CG2	3.04	0.40
1:A:8:PRO:HG2	1:A:11:ALA:HB2	2.04	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	142/155 (92%)	140 (99%)	2 (1%)	0	100	100
1	B	142/155 (92%)	141 (99%)	1 (1%)	0	100	100
1	C	152/155 (98%)	149 (98%)	3 (2%)	0	100	100
1	D	149/155 (96%)	146 (98%)	3 (2%)	0	100	100
All	All	585/620 (94%)	576 (98%)	9 (2%)	0	100	100

There are no Ramachandran outliers to report.

### 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	119/129 (92%)	118 (99%)	1 (1%)	73	87

Continued on next page...

Continued from previous page...

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	B	119/129 (92%)	119 (100%)	0	100	100
1	C	128/129 (99%)	128 (100%)	0	100	100
1	D	125/129 (97%)	125 (100%)	0	100	100
All	All	491/516 (95%)	490 (100%)	1 (0%)	87	94

All (1) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	77	VAL

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

Mol	Chain	Res	Type
1	D	-1	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](#)

4 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	EDO	A	201	-	3,3,3	0.44	0	2,2,2	0.38	0
2	EDO	D	201	-	3,3,3	0.41	0	2,2,2	0.38	0
3	GOL	B	201	-	5,5,5	1.05	0	5,5,5	0.10	0
4	PEG	C	201	-	6,6,6	0.48	0	5,5,5	0.56	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
2	EDO	A	201	-	-	1/1/1/1	-
2	EDO	D	201	-	-	0/1/1/1	-
3	GOL	B	201	-	-	4/4/4/4	-
4	PEG	C	201	-	-	3/4/4/4	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (8) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	B	201	GOL	O1-C1-C2-C3
3	B	201	GOL	O2-C2-C3-O3
4	C	201	PEG	O2-C3-C4-O4
3	B	201	GOL	C1-C2-C3-O3
3	B	201	GOL	O1-C1-C2-O2
2	A	201	EDO	O1-C1-C2-O2
4	C	201	PEG	C4-C3-O2-C2
4	C	201	PEG	C1-C2-O2-C3

There are no ring outliers.

No monomer is involved in short contacts.

## 5.7 Other polymers [i](#)

There are no such residues in this entry.

## 5.8 Polymer linkage issues

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	144/155 (92%)	0.34	2 (1%) 73 71	20, 30, 39, 49	0
1	B	144/155 (92%)	0.31	2 (1%) 73 71	20, 30, 39, 51	0
1	C	152/155 (98%)	0.37	1 (0%) 84 82	17, 28, 39, 50	2 (1%)
1	D	151/155 (97%)	0.30	3 (1%) 65 62	22, 27, 37, 53	0
All	All	591/620 (95%)	0.33	8 (1%) 73 71	17, 28, 39, 53	2 (0%)

All (8) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	17	ALA	3.5
1	B	17	ALA	2.6
1	D	18	GLY	2.6
1	D	149	GLY	2.5
1	D	80	PHE	2.3
1	A	7	GLN	2.3
1	C	80	PHE	2.2
1	B	108	THR	2.1

### 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
3	GOL	B	201	6/6	0.79	0.13	28,37,46,47	0
4	PEG	C	201	7/7	0.80	0.16	24,30,35,36	0
2	EDO	A	201	4/4	0.82	0.13	26,32,36,39	0
2	EDO	D	201	4/4	0.84	0.12	25,31,33,33	0

## 6.5 Other polymers [i](#)

There are no such residues in this entry.