wwPDB X-ray Structure Validation Summary Report (i)

Feb 1, 2016 – 08:14 AM GMT

PDB ID	:	3DUT
Title	:	The high salt (phosphate) crystal structure of deoxy hemoglobin E (GLU26LYS) at physiological pH (pH 7.35)
Authors	:	Malashkevich, V.N.; Balazs, T.C.; Almo, S.C.; Hirsch, R.E.
Deposited on	:	2008-07-17
Resolution	:	1.55 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
http://wwpdb.org/validation/2016/XrayValidationReportHelp
with specific help available everywhere you see the (i) symbol.

The following versions of software and data (see references (1)) were used in the production of this report:

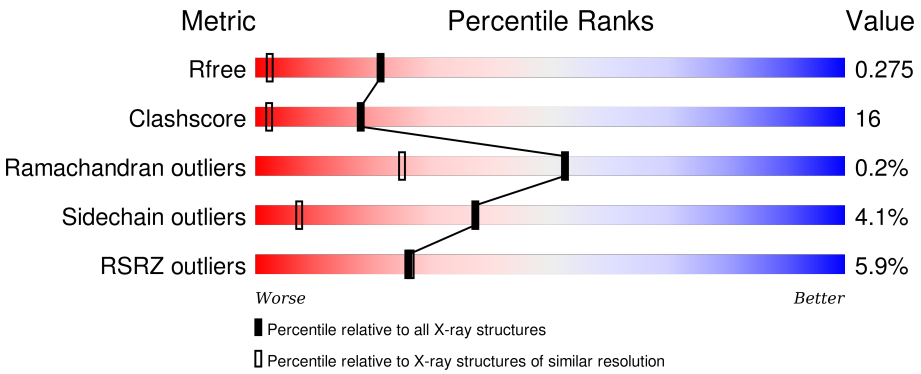
MolProbity	:	4.02b-467
Mogul	:	1.7 (RC4), CSD as536be (2015)
Xtriage (Phenix)	:	1.9-1692
EDS	:	rb-20026688
Percentile statistics	:	20151230.v01 (using entries in the PDB archive December 30th 2015)
Refmac	:	5.8.0135
CCP4	:	6.5.0
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	trunk26865

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 1.55 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}	91344	1665 (1.58-1.54)
Clashscore	102246	1014 (1.56-1.56)
Ramachandran outliers	100387	1704 (1.58-1.54)
Sidechain outliers	100360	1702 (1.58-1.54)
RSRZ outliers	91569	1668 (1.58-1.54)

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 on the lower bar indicate the fraction of residues that contain outliers for >=3, 2, 1 and 0 types of geometric quality criteria. 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	141	4%, 87%, 13%
1	C	141	7%, 76%, 23%, •
2	B	146	10%, 67%, 26%, 7%
2	D	146	3%, 80%, 17%, •

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	HEM	D	150	-	-	-	X

2 Entry composition (i)

There are 5 unique types of molecules in this entry. The entry contains 5013 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 Hemoglobin subunit alpha.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	141	1075	689	187	196	3	0	2	0
1	C	141	1069	685	187	194	3	0	0	0

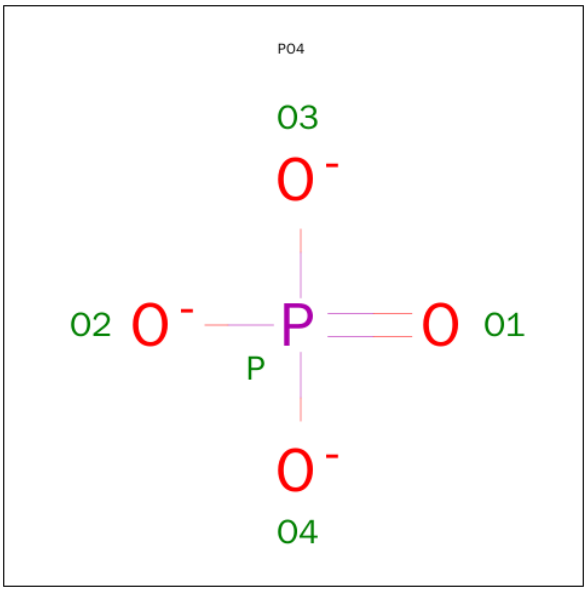
- Molecule 2 is a protein called Hemoglobin subunit beta.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
2	B	146	1129	729	196	201	3	0	1	0
2	D	146	1128	728	197	200	3	0	1	0

There are 2 discrepancies between the modelled and reference sequences:

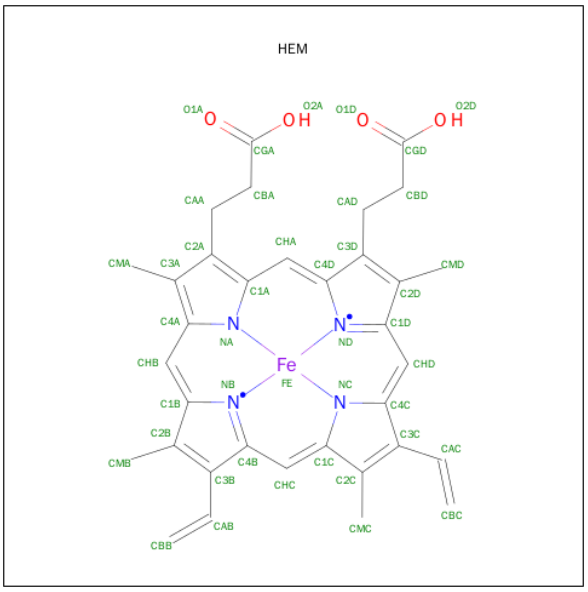
Chain	Residue	Modelled	Actual	Comment	Reference
B	26	LYS	GLU	ENGINEERED	UNP P68871
D	26	LYS	GLU	ENGINEERED	UNP P68871

- Molecule 3 is PHOSPHATE ION (three-letter code: PO4) (formula: O_4P).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	O	P		
3	B	1	5	4	1	0	0
			Total	O	P		
3	C	1	5	4	1	0	0

- Molecule 4 is PROTOPORPHYRIN IX CONTAINING FE (three-letter code: HEM) (formula: $C_{34}H_{32}FeN_4O_4$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	Fe	N	O		
4	A	1	43	34	1	4	4	0	0

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Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	Fe	N	O		
4	B	1	43	34	1	4	4	0	0
4	C	1	43	34	1	4	4	0	0
4	D	1	43	34	1	4	4	0	0

- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
5	A	114	114	114	0	0
5	B	114	114	114	0	0
5	C	94	94	94	0	0
5	D	108	108	108	0	0

3 Residue-property plots (i)

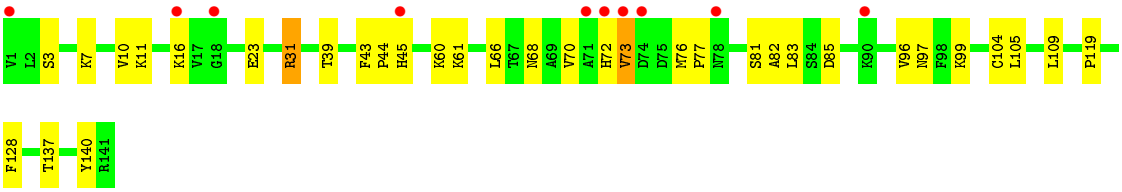
These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according 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: Hemoglobin subunit alpha

Chain A:

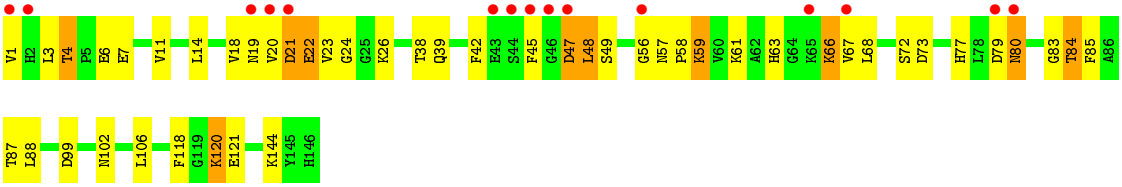
- Molecule 1: Hemoglobin subunit alpha

Chain C:



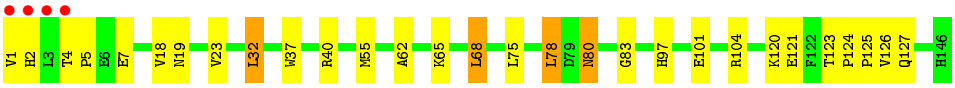
- Molecule 2: Hemoglobin subunit beta

Chain B:



- Molecule 2: Hemoglobin subunit beta

Chain D:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α, β, γ	53.26Å 79.63Å 62.35Å 90.00° 98.66° 90.00°	Depositor
Resolution (Å)	9.99 – 1.55 9.95 – 1.55	Depositor EDS
% Data completeness (in resolution range)	96.9 (9.99-1.55) 96.9 (9.95-1.55)	Depositor EDS
R_{merge}	0.04	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	3.17 (at 1.55Å)	Xtriage
Refinement program	REFMAC 5.4.0069	Depositor
R, R_{free}	0.218 , 0.277 0.217 , 0.275	Depositor DCC
R_{free} test set	3587 reflections (5.24%)	DCC
Wilson B-factor (Å^2)	22.0	Xtriage
Anisotropy	0.219	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.45 , 58.6	EDS
Estimated twinning fraction	No twinning to report.	Xtriage
L-test for twinning[2]	$< \|L\| > = 0.51$, $< L^2 > = 0.34$	Xtriage
Outliers	0 of 71980 reflections	Xtriage
F_o,F_c correlation	0.96	EDS
Total number of atoms	5013	wwPDB-VP
Average B, all atoms (Å^2)	27.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.88% 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, 0.375 respectively for untwinned datasets, and 0.333, 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: HEM, PO4

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	0.76	0/1109	0.83	1/1507 (0.1%)
1	C	0.79	1/1097 (0.1%)	0.86	1/1491 (0.1%)
2	B	0.80	0/1162	0.92	2/1577 (0.1%)
2	D	0.93	1/1161 (0.1%)	1.03	3/1576 (0.2%)
All	All	0.82	2/4529 (0.0%)	0.92	7/6151 (0.1%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	104	CYS	CB-SG	-6.95	1.70	1.82
2	D	37	TRP	CZ3-CH2	5.10	1.48	1.40

The worst 5 of 7 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	D	32	LEU	CB-CG-CD1	7.60	123.92	111.00
1	C	31	ARG	NE-CZ-NH2	-7.41	116.60	120.30
2	B	99	ASP	CB-CG-OD1	-6.64	112.32	118.30
2	D	40	ARG	NE-CZ-NH1	6.54	123.57	120.30
2	D	40	ARG	NE-CZ-NH2	-5.96	117.32	120.30

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	1075	0	1083	10	0
1	C	1069	0	1073	29	0
2	B	1129	0	1131	78	0
2	D	1128	0	1131	22	0
3	B	5	0	0	0	0
3	C	5	0	0	1	0
4	A	43	0	30	0	0
4	B	43	0	30	8	0
4	C	43	0	30	5	0
4	D	43	0	30	1	0
5	A	114	0	0	2	1
5	B	114	0	0	5	1
5	C	94	0	0	6	0
5	D	108	0	0	2	0
All	All	5013	0	4538	144	1

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 16.

The worst 5 of 144 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)
4:B:150:HEM:HBA2	4:B:150:HEM:HHA	1.23	1.09
2:B:4:THR:HG22	2:B:7:GLU:H	1.21	1.03
2:B:57:ASN:OD1	2:B:59:LYS:HB2	1.59	1.01
2:B:24:GLY:N	2:B:68:LEU:HD12	1.74	1.00
2:D:4:THR:OG1	2:D:5:PRO:HD2	1.60	1.00

All (1) 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)
5:A:161:HOH:O	5:B:294:HOH:O[2_646]	2.11	0.09

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	141/141 (100%)	136 (96%)	4 (3%)	1 (1%)	26	6
1	C	139/141 (99%)	136 (98%)	3 (2%)	0	100	100
2	B	145/146 (99%)	142 (98%)	3 (2%)	0	100	100
2	D	145/146 (99%)	141 (97%)	4 (3%)	0	100	100
All	All	570/574 (99%)	555 (97%)	14 (2%)	1 (0%)	52	25

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	75	ASP

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	115/113 (102%)	115 (100%)	0	100	100
1	C	113/113 (100%)	111 (98%)	2 (2%)	66	36
2	B	119/118 (101%)	107 (90%)	12 (10%)	9	0
2	D	119/118 (101%)	113 (95%)	6 (5%)	30	4
All	All	466/462 (101%)	446 (96%)	20 (4%)	37	6

5 of 20 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
2	B	84	THR
2	B	120	LYS
2	D	78	LEU
2	B	79	ASP
2	B	80	ASN

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 13 such sidechains are listed below:

Mol	Chain	Res	Type
2	B	80	ASN
2	B	102	ASN
1	C	97	ASN
2	B	77	HIS
1	C	68	ASN

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 carbohydrates in this entry.

5.6 Ligand geometry (i)

6 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	HEM	A	150	1	30,50,50	2.55	9 (30%)	24,82,82	2.51	10 (41%)
3	PO4	B	147	-	4,4,4	0.55	0	6,6,6	0.25	0
4	HEM	B	150	2	30,50,50	2.77	9 (30%)	24,82,82	2.74	10 (41%)
3	PO4	C	142	-	4,4,4	0.65	0	6,6,6	0.27	0
4	HEM	C	150	1	30,50,50	2.41	8 (26%)	24,82,82	2.53	12 (50%)
4	HEM	D	150	2	30,50,50	2.17	6 (20%)	24,82,82	2.58	11 (45%)

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	HEM	A	150	1	-	0/10/54/54	0/0/8/8
3	PO4	B	147	-	-	0/0/0/0	0/0/0/0
4	HEM	B	150	2	-	0/10/54/54	0/0/8/8
3	PO4	C	142	-	-	0/0/0/0	0/0/0/0
4	HEM	C	150	1	-	0/10/54/54	0/0/8/8
4	HEM	D	150	2	-	0/10/54/54	0/0/8/8

The worst 5 of 32 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	B	150	HEM	C3B-C4B	-9.42	1.43	1.51
4	A	150	HEM	C3B-C4B	-8.98	1.43	1.51
4	D	150	HEM	C3B-C4B	-8.80	1.44	1.51
4	C	150	HEM	C3B-C4B	-7.98	1.44	1.51
4	B	150	HEM	C3D-C4D	-6.65	1.43	1.51

The worst 5 of 43 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
4	B	150	HEM	C3B-CAB-CBB	-4.83	117.05	124.46
4	B	150	HEM	CBA-CAA-C2A	-4.40	104.65	112.53
4	D	150	HEM	CMA-C3A-C4A	-4.22	121.38	128.36
4	C	150	HEM	CMA-C3A-C4A	-3.95	121.83	128.36
4	C	150	HEM	CBD-CAD-C3D	-3.46	103.47	113.55

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

4 monomers are involved in 15 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	B	150	HEM	8	0
3	C	142	PO4	1	0
4	C	150	HEM	5	0
4	D	150	HEM	1	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	141/141 (100%)	0.25	5 (3%) 48 51	18, 24, 39, 47	0
1	C	141/141 (100%)	0.30	10 (7%) 19 19	17, 25, 38, 43	0
2	B	146/146 (100%)	0.71	15 (10%) 9 9	19, 28, 42, 53	0
2	D	146/146 (100%)	0.33	4 (2%) 58 62	13, 24, 36, 52	0
All	All	574/574 (100%)	0.40	34 (5%) 26 26	13, 25, 40, 53	0

The worst 5 of 34 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	1	VAL	8.2
2	B	46	GLY	4.9
2	D	2	HIS	4.5
2	B	2	HIS	4.2
2	B	56	GLY	4.0

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 carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors(Å^2)	Q<0.9
4	HEM	D	150	43/43	0.94	0.13	2.54	15,19,30,35	0
4	HEM	A	150	43/43	0.97	0.10	1.03	19,21,29,32	0
4	HEM	C	150	43/43	0.94	0.13	0.94	20,23,31,34	0
3	PO4	C	142	5/5	0.96	0.16	0.66	34,42,44,44	0
3	PO4	B	147	5/5	0.93	0.14	0.60	50,50,51,54	0
4	HEM	B	150	43/43	0.92	0.12	0.51	22,24,30,32	0

6.5 Other polymers (i)

There are no such residues in this entry.