

MELBOURNE, AUSTRALIA, 20 - 23 SEPTEMBER 2011

**BUFR template for AMDAR, version 6
and descriptors for AMDAR data**

Submitted by Eva Červená (Czech Republic)

Summary and Purpose of Document

This document contains BUFR Template for AMDAR data, v. 6, BUFR/CREX descriptors required in this template and new entries in Code Table 0 33 026 "Moisture Quality".

ACTION PROPOSED

The meeting is invited to discuss the content of this document and to recommend the included descriptors as pre-operational.

References:

- [1] Manual on Codes, WMO-No. 306, Volume I.2
- [2] First Meeting of the Inter-Programme Expert Team on Data Representation and Codes, Final Report. Geneva, 15 to 18 September 2009.
- [3] Joint Meeting of WIGOS Pilot Project for AMDAR and AMDAR Panel Management Group, Final Report. De Bilt, The Netherlands, 28 February to 4 March 2011.

1. Background

The First Meeting of the Inter-Programme Expert Team on Data Representation and Codes (Geneva, 15 to 18 September 2009) considered requirements of the WIGOS Pilot Project for AMDAR for a standardized BUFR Template for AMDAR and approved template 3 11 010, version 4 and several new descriptors for validation [2]. A BUFR message was encoded/decoded by the Czech Hydrometeorological Institute (CHMI), using in-house SW and ECMWF SW, and consequently by the Meteorological Service of Canada and by the IBL Software Engineering.

The Joint Meeting of WIGOS Pilot Project for AMDAR and AMDAR Panel Management Group (De Bilt, 28 February to 4 March 2011) reviewed the outcomes relating to the development of the Standardized Template for AMDAR that were made at the 13th Session of the AMDAR Panel and the 2nd Session of the ET-AIR. It also reviewed the suggested changes proposed to the Version 4 BUFR Template (3 11 010) made at the 4th Session of the WIGOS Pilot Project for AMDAR, Geneva, Switzerland in August 2010. These suggested changes included; changing the 0 07 004 Pressure descriptor to 0 07 010 Pressure Altitude (Flight Level) as well as increasing the resolution for mass mixing ratio. The Joint Meeting agreed that the AMDAR BUFR Template would include the new Code Table, 0 02 170 "Aircraft Humidity Sensor", as well as the expanded Code Table 0 33 026 "Moisture Quality". It was agreed that "the validation process would include a preliminary check of the content and correctness by Dr Červená. Following this preliminary check a more formal validation process still would be required and should be undertaken by both producers and users of the AMDAR data." The Joint Meeting proposed that the E-AMDAR and the USA AMDAR Programs would be involved on the data production side of the validation testing process [3].

The AMDAR BUFR Template, version 5 and the newly proposed descriptors were consequently submitted to IPET DRC and discussed at the E-AMDAR TAG meeting, Plitvice, 15-17 March 2011. The outcome of the E-AMDAR TAG proposals and comments from IPET-DRC were introduced in the version 5 of the AMDAR BUFR Template [3]. A BUFR message, containing this AMDAR template and all new descriptors, has been encoded and decoded in CHMI by two independent SW.

In July 2011, UKMO and ECMWF offered their participation in validation of the template using data from actual AMDAR messages. Dr Enrico Fucile expressed the requirement of ECMWF for availability of relative humidity with higher precision in the AMDAR template, this requirement later supported by information from the WMO Secretariat that precision for reporting of relative humidity via ARINC 620 would be increased to 0.01 %. Consequently the template was modified, becoming AMDAR BUFR Template, version 6, and a corresponding BUFR message was produced by two independent SW in CHMI, and decoded by ECMWF. AMDAR experts were informed on availability of a more sophisticated operator 207Y that might be used instead of operators 201Y and 202Y to change data width and scale of mixing ratio 0 13 002 and relative humidity 0 13 003.

Validation of the BUFR template for AMDAR is planned to be finalized by November 2011.

2. BUFR/CREX descriptors

The following descriptors are proposed to become pre-operational:

Table reference	Element name	BUFR				CREX		
		Unit	Scale	Reference value	Data width	Unit	Scale	Data width
0 11 100	Aircraft true airspeed	m s ⁻¹	1	0	12	m s ⁻¹	1	4
0 11 101	Aircraft ground speed u-component	m s ⁻¹	1	-4096	13	m s ⁻¹	1	4
0 11 102	Aircraft ground speed v-component	m s ⁻¹	1	-4096	13	m s ⁻¹	1	4
0 11 103	Aircraft ground speed w-component	m s ⁻¹	1	-512	10	m s ⁻¹	1	3
0 11 104	Aircraft true heading	Degree true	0	0	9	Degree true	0	3
0 10 053	Global Navigation Satellite System Altitude	m	0	-1000	17	m	0	5
0 01 110	Aircraft tail number	CCITT IA5	0	0	48	CCITT IA5	0	6
0 01 111	Origination airport	CCITT IA5	0	0	24	CCITT IA5	0	3
0 01 112	Destination airport	CCITT IA5	0	0	24	CCITT IA5	0	3
0 11 105	EDR algorithm version	Numeric	0	0	6	Numeric	0	2
0 11 106	Running minimum confidence	Numeric	1	0	4	Numeric	1	2
0 11 107	Maximum number bad inputs	Numeric	0	0	5	Numeric	0	2
0 11 108	Peak Location	Numeric	1	0	4	Numeric	1	2
0 11 109	Number of good EDR	Numeric	0	0	4	Numeric	0	2
0 02 170	Aircraft humidity sensors	Code table	0	0	6	Code table	0	2

0 02 170 **Aircraft humidity sensors**

Code Figure	Sensor Type
0	SpectraSensors WVSS-II, Version 1
1	SpectraSensors WVSS-II, Version 2
2	SpectraSensors WVSS-II, Version 3
3 – 61	Reserved
62	Other
63	Missing Value

3. New entries in Code Tables 0 31 021 (Associated field significance) and 0 33 026 (Moisture Quality).

Code figure 8 (Two bit quality information) is to be added as in the Code table 0 31 021 (Associated field significance):

0 31 021
Associated field significance

Code figure	
8	0 - Not suspected 1 - Suspected 2 - Reserved 3 - Information not required

New code figures 10 to 15 have been introduced into 0 33 026 (Moisture quality):

0 33 026
Moisture quality

Code figure	
0	Normal operations - measurement mode
1	Normal operations - non-measurement mode
2	Small RH
3	Humidity element is wet
4	Humidity element contaminated
5	Heater fail
6	Heater fail and wet/contaminated humidity element
7	At least one of the input parameters used in the calculation of mixing ratio is invalid
8	Numeric error
9	Sensor not installed
10	Calculated RH > 100%
11	Input laser power too low
12	Probe WV Temp. out of range
13	Probe WV Press. out of range
14	Spectral line out of range
15	No laser output
16-62	Reserved
63	Missing value

4. BUFR template for AMDAR, version 6

The following template is BUFR template for AMDAR, version 5 (21 March 2011) recommended by Joint Meeting of WIGOS Pilot Project for AMDAR and AMDAR Panel Management Group for validation [3], with additional modification of scale and data width of 0 13 003 (Relative humidity).

Notes included under the template have explanatory character and/or are reflecting development of the template. Therefore they are not meant for introduction into BUFR table D, Category 11. The same applies to the middle column where optional inclusion of some elements is suggested.

BUFR TEMPLATE FOR AMDAR, 3 11 010, version 6 (9 September 2011)

0	01	008		Aircraft identification ⁽¹⁾
0	01	023		Sequence number ⁽²⁾
0	01	006		Flight number ⁽³⁾
0	01	110		Aircraft tail number ^{(1) (4)}
0	01	111		Origination airport ⁽⁴⁾
0	01	112		Destination airport ⁽⁴⁾
2	04	002		Add associated field (of 2 bits) ^{(19) (20)}
0	31	021		Associated field significance ^{(19) (20)} (= 8 Two bits quality information)
3	01	011		Year, month and day
3	01	013		Hour, minute and second
3	01	021		Latitude and longitude (high accuracy)
0	07	010		Pressure Altitude (Flight Level) ⁽⁵⁾
0	10	053		GNSS Altitude ⁽⁴⁾
0	08	009		Detailed phase of flight ⁽⁶⁾
0	11	001		Wind direction
0	11	002		Wind speed
0	02	064		Aircraft roll angle quality ⁽²⁵⁾
0	11	100	Optional	Aircraft true airspeed ⁽⁷⁾
0	11	101	Optional	Aircraft ground speed (u-component) ⁽⁴⁾
0	11	102	Optional	Aircraft ground speed (v-component) ⁽⁴⁾
0	11	103	Optional	Aircraft ground speed (w-component) ⁽⁴⁾
0	11	104	Optional	Aircraft true heading ⁽⁴⁾
0	12	101		Temperature/air temperature ⁽⁸⁾
0	02	170		Aircraft humidity sensors ^{(4) (24)}
2	01	138		Change data width ⁽²⁶⁾
2	02	131		Change scale ⁽²⁶⁾
0	13	002		Mixing ratio ⁽²²⁾
2	02	000		Cancel change scale ⁽²⁶⁾
2	01	000		Cancel change data width ⁽²⁶⁾
2	01	135		Change data width ⁽²⁷⁾
2	02	130		Change scale ⁽²⁷⁾
0	13	003		Relative humidity
2	02	000		Cancel change scale ⁽²⁷⁾
2	01	000		Cancel change data width ⁽²⁷⁾
1	01	000		Delayed replication of 1 descriptor
0	31	000		Short delayed descriptor replication factor
0	12	103	Optional	Dew-point temperature ⁽⁹⁾
0	33	026		Moisture quality ⁽²³⁾
1	01	000		Delayed replication of 1 descriptor
0	31	000		Short delayed descriptor replication factor
0	20	042	Optional	Airframe icing ⁽¹⁰⁾
1	03	000		Delayed replication of 3 descriptors
0	31	000		Short delayed descriptor replication factor
0	20	043	Optional	Peak liquid water content ⁽¹¹⁾
0	20	044	Optional	Average liquid water content ⁽¹¹⁾
0	20	045	Optional	Supercooled large droplet (SLD) conditions ⁽¹¹⁾
1	01	000		Delayed replication of 1 descriptor
0	31	000		Short delayed descriptor replication factor

0	33	025	Optional	ACARS interpolated values indicator ⁽¹²⁾
1	03	000		Delayed replication of 3 descriptors ⁽¹³⁾
0	31	001		Delayed descriptor replication factor ⁽¹⁴⁾
0	11	075	Optional	Mean turbulence intensity (EDR)
0	11	076	Optional	Peak turbulence intensity (EDR)
0	11	039	Optional	Extended time of occurrence of peak EDR ⁽¹⁵⁾
1	02	000		Delayed replication of 2 descriptors
0	31	000		Short delayed descriptor replication factor
0	11	037	Optional	Turbulence index (EDR)
0	11	077	Optional	Reporting interval or averaging time for EDR ⁽¹⁶⁾
1	03	000		Delayed replication of 3 descriptors
0	31	000		Short delayed descriptor replication factor
0	11	034	Optional	Vertical gust velocity ⁽¹⁷⁾
0	11	035	Optional	Vertical gust acceleration ⁽¹⁷⁾
0	11	036	Optional	Maximum derived equivalent vertical gust speed ⁽¹⁷⁾
2	04	000		Cancel add associated field ⁽¹⁹⁾⁽²⁰⁾
1	19	000		Delayed replication of 19 descriptors ⁽¹⁸⁾
0	31	001		Delayed descriptor replication factor ⁽¹⁸⁾
3	01	011		Year, month and day
3	01	013		Hour, minute and second
3	01	021		Latitude and longitude (high accuracy)
0	07	007		Height
0	11	105	Optional	EDR algorithm version ⁽⁴⁾
2	04	007		Add associated field (of 7 bits) ⁽²¹⁾
0	31	021		Associated field significance ⁽²¹⁾ (= 7 Percentage confidence)
0	11	076	Optional	Peak turbulence intensity (EDR)
0	11	075	Optional	Mean turbulence intensity (EDR)
2	04	000		Cancel add associated field ⁽²¹⁾
0	11	106	Optional	Running minimum confidence ⁽⁴⁾
0	11	107	Optional	Maximum number bad inputs ⁽⁴⁾
0	11	108	Optional	Peak Location ⁽⁴⁾
0	11	109	Optional	Number of good EDR ⁽⁴⁾
0	12	101	Optional	Temperature/air temperature
0	11	001	Optional	Wind direction
2	01	130	Optional	Change data width
0	11	084	Optional	Wind speed
2	01	000	Optional	Cancel change data width

Notes for Standardized BUFR Template for AMDAR data 3 11 010, version 6:

(1) Aircraft identifier 0 01 008 can cope with ASDAR, ADS and other AMDAR identities. ADS reports use a 24-bit ICAO airframe identifier, equating to an 8-character BCD number. Look at developing a standard naming convention for the various AMDAR regions and/or programmes. The WIGOS meeting agreed that additional information such aircraft type and navigation systems would be part of the Meta data, not part of the Standardized BUFR Template for AMDAR. It was noted that AMDAR Meta data would be addressed by the WIGOS Pilot Project for AMDAR. This identifier is used for masking the identity of the aircraft. For the real identification, 0 01 110 can be used and is therefore classed as optional.

(2) The sequence number is a simple observation count to be included in the down-linked message. It should be reset at 0000 UTC each day and can be useful for quality control, data management and archiving purposes. The WIGOS meeting has made the recommendation that if this parameter is not used

by an operational AMDAR programme or NWP Centre then this parameter be removed from the new Standardized BUFR Template for AMDAR.

(3) 0 01 006 (Flight number) will assist with the quality control of aircraft track data, by providing information on the route the aircraft is expected to take, including information on the departure airport and the expected arrival airports. Presently 8 characters has been used as an estimate as the maximum length for any given flight number.

(4) Refer to the following table for the required BUFR descriptors including the units, scale, reference value and data width.

Table reference	Element name	BUFR			
		Unit	Scale	Reference value	Data width
0 11 100	Aircraft true airspeed	m s ⁻¹	1	0	12
0 11 101	Aircraft ground speed u-component	m s ⁻¹	1	-4096	13
0 11 102	Aircraft ground speed v-component	m s ⁻¹	1	-4096	13
0 11 103	Aircraft ground speed w-component	m s ⁻¹	1	-512	10
0 11 104	Aircraft true heading	Degree true	0	0	9
0 10 053	Global Navigation Satellite System Altitude	m	0	-1000	17
0 01 110	Aircraft tail number	CCITT IA5	0	0	48
0 01 111	Origination airport	CCITT IA5	0	0	24
0 01 112	Destination airport	CCITT IA5	0	0	24
0 11 105	EDR algorithm version	Numeric	0	0	6
0 11 106	Running minimum confidence	Numeric	1	0	4
0 11 107	Maximum number bad inputs	Numeric	0	0	5
0 11 108	Peak Location	Numeric	1	0	4
0 11 109	Number of good EDR	Numeric	0	0	4
0 02 170	Aircraft humidity sensors	Code table	0	0	6

Proposal for new AMDAR descriptors in 3 11 010, version 5.

(These descriptors were proposed for version 5 and no change has been done with version 6)

- (5) Following advice from the airline industry it was recommended that Pressure (0 07 004) not be included as the primary height field and that Pressure Altitude (PALT) (0 07 010) replace this field. Note: PALT should be identical to that of the previously used AMDAR primary height field Flight Level (0 07 010), it is recommended that the definition of Flight Level include definition for PALT (h_1, h_1, h_1 as per the FM42 definition) to remove confusion (it refers to Pressure Altitude as a measure of height relative to standard datum plane of 1013.2 hPa).
- (6) This phase of flight table is expanded to indicate wind quality from roll angle, or roll and pitch combined and also to indicate the method of ascent and descent observation interval selection either by time or pressure increments. The WIGOS meeting agreed that the Phase of flight 0 08 004 would not be included in the new Standardized BUFR Template for AMDAR as the required level of detail has been incorporated in the detailed phase of flight 0 08 009. The WIGOS meeting also discussed whether there is a requirement for adding a new condition to the detailed phase of flight 0 08 009 that would cover an aircraft being placed in a holding pattern.
- (7) Refer to AMDAR Reference Manual for definition.
- (8) This parameter has been renamed Temperature/air temperature.
- (9) 0 12 103 Dew-point temperature had been introduced in the templates for AMDAR profile data to simulate radiosounding data.
- (10) The old ACARS airframe icing code table 0 20 041 is not included.
- (11) A special automatic icing report, including these elements, is expected to become available from some aircraft and a down-link code has been published.
- (12) 0 33 025 ACARS interpolated values was primarily used in the USA AMDAR Programme to indicate time and position being reported or interpolated. The name for this element has been changed to ACARS interpolated values indicator.
- (13) Delayed replication 1 03 000 refers to the following three descriptors 0 11 075, 0 11 076 and 0 11 039 to allow reporting of the Extended time of occurrence of peak EDR of all included values of 0 11 076 (Peak (EDR)). This allows each turbulence peak to be reported.

Explanatory remarks to Note (13):

According to Note (14), up to ten values of 0 11 076 (Peak (EDR)) may be reported. However, 0 11 039 (Extended time of occurrence of peak EDR) was included only once in the template 3 11 010, version 0. Therefore, it was not clear to which out of those ten values of 0 11 076, the time specification 0 11 039 referred. If it had been the maximum value, the name of 0 11 039 should have been modified to read "Extended time of occurrence of maximum peak EDR". If the time information on all the reported values of 0 11 076 (Peak (EDR)) is required, then 0 11 039 (Extended time of occurrence of peak EDR) should be included under the delayed replication as shown in the proposed template 3 11 010, version 5

- (14) Some aircraft report up to 10 pairs of (EDR) values per observation. The corresponding times and position could be found by interpolation from the previous report. If the aircraft does not report it the number of replication 0 31 001 is set to zero.
- (15) 0 11 039 allows observation intervals up to one hour. 0 11 038 allows up to 15 minutes only whereas observation intervals of 30 minutes or more are commonly used, hence 0 11 038 had been replaced by 0 11 039.

(16) The EDR observing interval and associated averaging time differs according to individual observing schedule and cannot be assumed to be identical to the observation interval for the main elements. It is desirable to include this information in the coded data.

(17) Vertical gust velocity 0 11 034, Vertical gust acceleration 0 11 035 and Maximum derived equivalent vertical gust speed 0 11 036 have been added to meet the request for reflecting all entries of 3 11 004 in the Standardized BUFR template for AMDAR. The current ICAO standard for automated turbulence reporting is EDR.

(18) Up to 254 EDR reports may be included in a BUFR message. If the aircraft does not report them, the number of replication 0 31 001 is set to zero.

(19) Operator descriptor 2 04 Y has been introduced for representation of AMDAR quality information instead of flag table 0 33 079 () used in the previous versions of the AMDAR template 3 11 010. Some elements (such as Wind Speed, Wind Direction, Air Temperature) may appear more than once in the data described by 3 11 010. Operator descriptor 2 04 Y allows to assign unambiguously the required quality information to the element to which it refers.

(20) Each of the following elements, apart from delayed replication factors 0 31 000 and 0 31 001, shall be preceded by two bits providing information on the element being suspected or not. If the quality information on the element is not required, the associated field shall be set to 3. For this purpose, **code figure 8 (Two bit quality information)** is proposed to be used as defined in the Code table 0 31 021 (Associated field significance) :

0 31 021

Code figure	
8	0 - Not suspected 1 - Suspected 2 - Reserved 3 - Information not required

(21) Peak turbulence intensity (EDR) and Mean turbulence intensity (EDR) shall be preceded by seven bit information containing percentage confidence of Peak turbulence intensity (EDR) and Mean turbulence intensity (EDR), respectively.

(22) Mixing ratio 0 13 002 is to be used for water vapour mass mixing ratio

(23) New code figures 10 to 15 have been introduced into 0 33 026 (Moisture quality) as shown in the table below.

0 33 026 (Moisture quality)

Code figure	
0	Normal operations - measurement mode
1	Normal operations - non-measurement mode
2	Small RH
3	Humidity element is wet
4	Humidity element contaminated
5	Heater fail
6	Heater fail and wet/contaminated humidity element
7	At least one of the input parameters used in the calculation of mixing ratio is invalid
8	Numeric error
9	Sensor not installed
10	Calculated RH > 100%
11	Input laser power too low
12	Probe WV Temp. out of range
13	Probe WV Press. out of range
14	Spectral line out of range
15	No laser output
16-62	Reserved
63	Missing value

(24) A new entry 0 02 170 is proposed for Aircraft humidity sensors (Code table, 0, 0, 6):

Code Figure	Sensor Type	Status
0	SpectraSensors WVSS-II, Version 1	Operational
1	SpectraSensors WVSS-II, Version 2	Operational
2	SpectraSensors WVSS-II, Version 3	Operational
3 – 61	Reserved	
62	Other	
63	Missing Value	

(25) 0 02 063 (Aircraft Roll Angle, Value) will not be reported but 0 02 064 (Aircraft Roll Angle Quality, Code Table) will because this provides the required information on the Roll Angle (e.g. Code Figure 1, Bad, means Roll Angle > 5 degrees from vertical).

(26) This is used to increase scale 5 and data width 14 to scale 8 and data width 24 to cover the full range for water vapour mass mixing ratio being reported in kg kg^{-1} with precision in 10^{-8} of kg kg^{-1} .

(27) This is used to increase scale 0 and data width 7 of relative humidity to scale 2 and data width 14 to allow reporting relative humidity with precision in 0.01 %.