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ASSEMBLY — 40TH SESSION

TECHNICAL COMMISSION

Agenda Item 30: Other issues to be considered by the Technical Commission

SAFETY EVALUATION OF CONVERSION FACTOR (K) IN TEHRAN TMA

(Presented by Iran (Islamic Republic of))

EXECUTIVE SUMMARY

Conversion factor (K) is an agent that is related to temperature and altitude. It is used in conversion calculating indicated air speed (IAS) to true airspeed (TAS). In *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168), $ISA+15^{\circ c}$ is used as an instance, but this document has mentioned several times that the domestic information should be used not $ISA+15^{\circ c}$. If conversion factor (K) calculating is used correctly, it causes flight safety to increase. It is important that procedure designers elect temperature correctly and with regard to relationship "K" to ISA; if the procedure is not designed correctly, this can result in significant differences in the tracks that the aircraft fly. For designing procedures, the worst case conditions of maximum and minimum temperatures that could prevail should be considered.

Strategic Objectives:	This working paper relates to the Safety Strategic Objective.
Financial implications:	N/A
References:	Doc 8400, *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC) Doc 8168, *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS) IMO, Iranian Meteorological Organization

1. INTRODUCTION

1.1 Conversion factor (K) is an agent that is related to temperature and altitude. It is used in conversion calculating IAS to TAS. In PANS-OPS, $ISA + 15^{\circ C}$ is used as an instance, but this document has mentioned several times that the domestic information should be used not the $ISA + 15^{\circ C}$. If conversion factor (K) calculating is used correctly, it causes flight safety to increase. (Formula (1) and (2))

$$K = 171233 * [(288 \pm VAR) - 0.00198H]^{0.5} \div (288 - 0.00198H)^{2.628} \quad (1)$$

$$K = 171233 * [(288 \pm VAR) - 0.006496h]^{0.5} \div (288 - 0.006496h)^{2.628} \quad (2)$$

That H (altitude) by feet, h (altitude) by feet and VAR (temperature variable) is by degrees centigrade. [2]

1.2 An important aspect for procedure designers is elect temperature correctly and with regard to relationship “K” to ISA; if the procedure is not designed correctly, this can result in significant differences in the tracks that the aircraft fly.

1.3 For designing procedures, the worst-case conditions of maximum and minimum temperatures that could prevail should be considered. [2]

2. INFLUENCE OF CONVERSION FACTOR (K) ON THE OTHER SECTIONS

2.1 Speed (IAS, TAS)

In all design calculating, suppose speed based on TAS authorized. (Formula (3) and (4) [2]

$$TAS = V = IAS * K \quad (3)$$

or

$$TAS = 55.1085\sqrt{T}\sqrt{\sqrt{1 + 0.0023157\frac{IAS^2}{P}\left(1 + \frac{IAS^2}{1750200}\right)} - 1} \quad (4)$$

That T (temperature) is by Kelvin in $ISA + 15^{\circ C}$ and P (pressure) is by Hectopascal.

2.2 Importance of temperature (Temp) [2]

2.2.1 Considering the fact that conversion factor (K) is variable in different altitudes and temperatures, in every area for designing flight procedure minimum and maximum averages are needed. In below instances, for presentation of flight procedures, and using minimum speed authorized minimum temperature average in that area is needed; in PANS-OPS examples, $ISA - 10^{\circ C}$ is used:

a) missed approach;

b) minimum speed in final; and

c) minimum speed in MAPt tolerance.

2.2.2 Thus, for presentation of flight maximum speed authorized, maximum temperature average of that area is needed; in PANS-OPS examples, $ISA + 15^{\circ C}$ is used:

a) departure segment;

b) missed approach segment for maximum speed especially in turning;

c) missed approach segment for precision procedures;

d) maximum speed in final; and

e) maximum speed in missed approach tolerance.

2.2.3 In earliest and latest MAPt, MAPt to SOC distance calculating:

f) visual manoeuvring area;

g) global navigation satellite system (GNSS) arrival;

h) racetrack and reversal procedure area;

i) waypoint tolerance (ATT and XTT);

j) HLDG and RNP HLDG procedure; and

k) TAS in AWY.

Need for conversion for IAS to TAS with regard to Table III-1-1 and 2 from PANS-OPS.

2.2.4 With regard to instances of descript use of conversion factor (K) in conversion IAS to TAS, conversion factor (K) importance is perfectly clear and this factor in Iran area should be calculated and used with high accuracy.

3. AVERAGE EVALUATION OF TEMPERATURE MIN AND MAX

3.1 After minimum and maximum temperature value analysis (from Tehran synoptic station in pressure level 850 mbar to 400 mbar (below 19 500 ft) between 1986 up to 2015 (30 years)), below quantities prepared.

3.2 Table 1 is representation of maximum temperature up to 400 mbar (19 500 ft) that maximum temperature reported $+37.4^{\circ C}$ in July 1998 and in Table 2 annual maximum temperature average with $+18.35^{\circ C}$ value is calculated and thus Table 3 is representation of minimum temperature from surface up to 850 mbar (5 000 ft) that minimum temperature reported $-7.7^{\circ C}$ in March 1987 and in Table 4 annual minimum temperature average with $+16.22^{\circ C}$ value is calculated.

3.3 Results of calculating show that maximum temperature in hot months up to 400 mbar in 1986 up to 2015 (30 years) was $+25.64^{\circ C}$ that with 95 per cent confidence coefficient was $+26.4^{\circ C}$

(Table 5) and that minimum temperature in cold months up to 850 mbar in 1986 up to 2015 (30 years) was $+6.24^{\circ c}$ that with 95 per cent confidence coefficient was $+5.84^{\circ c}$ (Table 6).

3.4 Graph 1 is representation of annual average changes of maximum (MAX) temperature (in year hot months) in pressure level 400 mbar and minimum (MIN) temperature (in year cold months) in pressure level 850 mbar in 1986 to 2015. [1]

Table 1 – Annual changes of MAX Temp in pressure level 400 mbar in 1986 to 2015

MAX Temperature (Degrees) Years : 1986 Until 2015			
Year	MAX Temp	Year	MAX Temp
1986	35.50	2001	36.30
1987	35.90	2002	35.30
1988	35.00	2003	34.80
1989	35.07	2004	35.30
1990	33.80	2005	36.50
1991	36.60	2006	35.10
1992	36.00	2007	35.20
1993	33.60	2008	36.10
1994	33.80	2009	34.20
1995	36.20	2010	35.90
1996	36.00	2011	37.00
1997	34.60	2012	34.70
1998	35.50	2013	36.80
1999	37.40	2014	26.50
2000	30.80	2015	14.40
Results (1986 Until 2015)			
MAX (Jull 83)			37.40

Table 2–Annual average changes of MAX Temp in pressure level 400 mbar in 1986 to 2015

MAX Temperature average (Degrees) Years : 1986 Until 2015			
Year	MAX Temp	Year	MAX Temp
1986	18.61	2001	18.65
1987	18.09	2002	17.68
1988	15.95	2003	18.65
1989	17.66	2004	18.67
1990	16.57	2005	18.99
1991	17.35	2006	19.10
1992	16.90	2007	18.03
1993	15.85	2008	19.73
1994	22.19	2009	17.18
1995	22.08	2010	17.71
1996	27.54	2011	21.00
1997	20.39	2012	22.85
1998	16.86	2013	18,59
1999	17.98	2014	13.75
2000	14.85	2015	11.55
Results (1986 Until 2015)			
Average			18.37

Table 3 – Annual changes of MIN Temp in pressure level 850 mbar in 1986 to 2015

MIN Temperature (Degrees) Years : 1986 Until 2015			
Year	MIN Temp	Year	MIN Temp
1986	0.50	2001	2.60
1987	1.6	2002	2.10
1988	-7.7	2003	4.90
1989	-3.3	2004	2.00
1990	-2.3	2005	-0.90
1991	-2.1	2006	0.60
1992	-0.1	2007	1.70
1993	-3.6	2008	0.40
1994	7.2	2009	0.30
1995	6.5	2010	2.10
1996	16.9	2011	4.90
1997	4.9	2012	7.20
1998	-0.3	2013	0.50
1999	-0.8	2014	0.50
2000	-0.6	2015	8.70
Results (1986 Until 2015)			
MIN (MAR 72)			-7.70

Table 4 – Annual average changes of MIN Temp in pressure level 850 mbar in 1986 to 2015

MIN Temperature average (Degrees) Years : 1986 Until 2015			
Year	MIN Temp	Year	MIN Temp
1986	16.98	2001	16.26
1987	16.34	2002	15.73
1988	13.47	2003	16.52
1989	15.74	2004	16.90
1990	14.77	2005	16.08
1991	15.42	2006	17.17
1992	14.82	2007	15.99
1993	14.32	2008	15.70
1994	20.33	2009	14.53
1995	20.28	2010	15.67
1996	25.52	2011	18.85
1997	18.07	2012	20.82
1998	15.33	2013	14.67
1999	16.32	2014	11.49
2000	12.94	2015	09.65
Results (1986 Until 2015)			
Average			16.22

Table 5 – Annual average changes of MAX Temp (in year hot months) in pressure level 400 mbar in 1986 to 2015

MAX Temperature average (Degrees) Years : 1986 Until 2015			
Year	MAX Temp	Year	MAX Temp
1986	25.52	2001	26.04
1987	24.92	2002	24.99
1988	24.37	2003	24.97
1989	25.19	2004	25.77
1990	24.14	2005	26.99
1991	25.34	2006	26.62
1992	25.63	2007	25.54
1993	23.70	2008	27.27
1994	27.20	2009	25.22
1995	28.28	2010	24.39
1996	27.54	2011	25.75
1997	25.06	2012	27.61
1998	25.09	2013	25.82
1999	25.67	2014	26.15
2000	22.80	2015	--
Results (1986 Until 2015)			
Average			25.64
Average 95% Confidence-MAX			26.4

Table 6 – Annual average changes of MIN Temp (in year cold months) in pressure level 850 mbar in 86-15

MIN Temperature average (Degrees) Years : 1986 Until 2015			
Year	MIN Temp	Year	MIN Temp
1986	7.44	2001	6.63
1987	7.00	2002	5.75
1988	0.91	2003	8.08
1989	5.37	2004	7.22
1990	4.32	2005	5.21
1991	3.95	2006	6.84
1992	4.35	2007	5.73
1993	6.78	2008	5.64
1994	8.43	2009	4.43
1995	10.38	2010	7.00
1996	--	2011	7.93
1997	9.33	2012	8.83
1998	4.35	2013	5.72
1999	5.76	2014	2.67
2000	5.15	2015	9.55
Results (1986 Until 2015)			
Average			6.24
Average 95% Confidence - MIN			5.84

4. RESULTS AND RECOMMENDATION FOR INCREASING SAFETY

4.1 Table 7 represents an increase if safety coefficient is in different altitudes. For example, for IAS=220 kts, ALT =10 000 ft, K^{+15} =1.1958, S will be 263 kts but if we do new value $K^{+26.4}$ =1.2192, TAS will be 268 kts that in this situation for use of TAS, **safety coefficient (K) increases by 2%.** It is worthy of mention with regard to increase the aforementioned safety coefficient **increases by 2%** in Iran.

Table 7. Percentage of conversion factor (K) increase (Non-SI units)

(ALT-ft)	K	K	K	K	Increase of Safety 15º to 26.4º (%)
	ISA -10	ISA +5	ISA +15	ISA +26.4	K%
0	0.9825	1.0086	1.0257	1.0448	1.9
1000	1.0165	1.0236	1.0411	1.0606	1.9
2000	1.0317	1.0389	1.0567	1.0767	1.9
3000	1.0473	1.0546	1.0728	1.0932	1.9
4000	1.0631	1.0706	1.0892	1.1100	1.9
5000	1.0793	1.0869	1.1059	1.1273	1.9
10000	1.1662	1.1745	1.1958	1.2196	2.0
11000	1.1847	1.1932	1.2150	1.2394	2.0
12000	1.2038	1.2124	1.2347	1.2597	2.0
14000	1.2432	1.2522	1.2755	1.3017	2.0
15000	1.2637	1.2728	1.2967	1.3235	2.1
20000	1.3737	1.3837	1.4107	1.4409	2.1
21000	1.3974	1.4075	1.4353	1.4662	2.2
22000	1.4217	1.4320	1.4605	1.4922	2.2
23000	1.4466	1.4572	1.4863	1.5189	2.2
24000	1.4722	1.4829	1.5128	1.5462	2.2

4.2 With regard to instances mentioned in PANS-OPS and Tables III-F-1 and III-F-2, the minimum temperature average ($+5^{\circ C}$) with confidence coefficient and maximum temperature average ($+26.4^{\circ C}$) with confidence coefficient finally, will result in Tables 8 and 9, which ***will*** ***replace Tables III-F-1 and III-F-2*** (from PANS-OPS) for use in Iran. [1][2]

Table 8 – Conversion table for IAS to TAS calculations (Non-SI units)				
Replace to Table III-F-2 for use in Iran				
Conversion factor				
Altitude (Ft)	**ISA -10**	**ISA +5**	**ISA +15**	**ISA +26.4**
0.0	0.9825	1.0086	1.0257	1.0448
1000.0	1.0165	1.0236	1.0411	1.0606
2000.0	1.0317	1.0389	1.0567	1.0767
4000.0	1.0631	1.0706	1.0892	1.1100
6000.0	1.0959	1.1036	1.1231	1.1449
8000.0	1.1302	1.1382	1.1586	1.1814
10000.0	1.1662	1.1745	1.1958	1.2196
11000.0	1.1847	1.1932	1.2150	1.2394
12000.0	1.2038	1.2124	1.2347	1.2597
14000.0	1.2432	1.2522	1.2755	1.3017
15000.0	1.2637	1.2728	1.2967	1.3235
16000.0	1.2846	1.2939	1.3184	1.3458
18000.0	1.3280	1.3377	1.3634	1.3922
20000.0	1.3737	1.3837	1.4107	1.4409
22000.0	1.4217	1.4320	1.4605	1.4922
24000.0	1.4722	1.4829	1.5128	1.5462

Table 9 – Conversion table for IAS to TAS calculations (SI units)				
Replace to Table III-F-1 for use in Iran				
Conversion factor				
Altitude (m)	**ISA -10**	**ISA +5**	**ISA +15**	**ISA +26.4**
0.0	0.9825	1.0086	1.0257	1.0448
500.0	1.0262	1.0334	1.0511	1.0709
1000.0	1.0517	1.0590	1.0774	1.0979
1500.0	1.0780	1.0856	1.1046	1.1259
2000.0	1.1054	1.1132	1.1329	1.1550
2500.0	1.1338	1.1418	1.1623	1.1851
3000.0	1.1632	1.1715	1.1928	1.2165
3500.0	1.1939	1.2024	1.2245	1.2491
4000.0	1.2257	1.2345	1.2574	1.2830
4500.0	1.2588	1.2679	1.2917	1.3183
5000.0	1.2932	1.3026	1.3273	1.3550
5500.0	1.3290	1.3387	1.3644	1.3932
6000.0	1.3663	1.3763	1.4031	1.4331
6500.0	1.4052	1.4154	1.4434	1.4746
7000.0	1.4457	1.4563	1.4854	1.5179
7500.0	1.4879	1.4989	1.5292	1.5632

5. CONCLUSION

5.1 The Assembly is invited to advise States for evaluation of conversion factor (k) in all their country airspace for increasing safety coefficient.

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