

HANDBOOK OF AVIATION METEOROLOGY



3rd Edition

Met. 0.1006

METEOROLOGICAL OFFICE

Handbook of Aviation Meteorology

332/4060 INSTITUT
FÜR METEOROLOGIE U. KLIMATOLOGIE
UNIVERSITÄT HANNOVER
HERRENHAUSER STR. 2 - 30419 HANNOVER

LONDON : HMSO

CONTENTS

PART I

PHYSICAL PRINCIPLES

Chapter 1

THE ATMOSPHERE

Section *Page*

1.1	Meteorology — a branch of physics	3
1.2	Composition of the atmosphere.....	3
1.3	Structure of the atmosphere.....	4
1.4	Standard atmospheres.....	6

Chapter 2

PRESSURE

2.1	Introduction	8
2.2	Pressure at mean sea level	9
2.3	Pressure and height.....	11
2.4	Altimetry	14
2.5	Altimeter sub-scale settings.....	18

Chapter 3

TEMPERATURE

3.1	Introduction	21
3.2	Radiation	21
3.3	Temperature at and near the earth's surface	24
3.4	Transfer of heat by long-wave radiation	28
3.5	Adiabatic processes	29
3.6	The tephigram.....	31
3.7	Stability and instability.....	35
3.8	Vertical distribution of temperature	36
3.9	Temperature and aviation	39

Chapter 4

DENSITY

4.1	Introduction	41
4.2	Density of dry and moist air	41
4.3	Variations in density at the surface	42
4.4	Variation of density with height.....	43
4.5	Air density and aircraft performance.....	44

Chapter 5
MOTION OF THE ATMOSPHERE

5.1	Introduction	45
5.2	Pressure and wind.....	46
5.3	Wind near the earth's surface.....	53
5.4	Wind in the free atmosphere	63
5.5	Vertical motion of the atmosphere	67
5.6	Wind shear.....	77
5.7	Jet streams	80
5.8	Clear air turbulence	81
5.9	Wind and heat transference	84
5.10	Flight planning	85

Chapter 6
FORMATION OF CLOUD AND PRECIPITATION

6.1	Water in the atmosphere.....	88
6.2	General causes of cloud and precipitation.....	91
6.3	Cloud formation by turbulence.....	94
6.4	Fair weather cumulus	99
6.5	Instability clouds and showers	102
6.6	Orographic cloud and precipitation.....	108
6.7	Cloud and precipitation formed by widespread ascent	110
6.8	Precipitation in the form of ice.....	110

Chapter 7
THUNDERSTORMS

7.1	Conditions favourable for thunderstorm development.....	112
7.2	The structure of a single cell storm in temperate latitudes.....	113
7.3	Severe local storms.....	114
7.4	Tropical thunderstorms.....	117
7.5	Further characteristics of thunderstorms	117
7.6	Atmospheric electricity	121

Chapter 8
ICE ACCRETION ON AIRCRAFT

8.1	Introduction	123
8.2	Forms of airframe icing	123
8.3	Factors affecting the form of airframe icing	125
8.4	Ice accretion on aircraft	127
8.5	Effects of airframe icing on performance.....	130
8.6	Engine icing.....	132
8.7	Helicopter icing	134
8.8	Procedures in relation to icing risks	135

Chapter 9

VISIBILITY

9.1	Introduction	139
9.2	Some definitions.....	139
9.3	In-flight visibility	140
9.4	Causes of atmospheric obscurity	143
9.5	Fog and mist	144
9.6	Radiation fog	145
9.7	Advection fog	148
9.8	Steaming fog.....	149
9.9	Frontal fog	150
9.10	Visibility in cloud and precipitation.....	150
9.11	Wind-blown spray	151
9.12	Reduction of visibility by smoke.....	152
9.13	Reduction of visibility by solid matter	152
9.14	Artificial dispersal of fog	155

Chapter 10

SPECIAL TOPICS

10.1	Condensation trails	157
10.2	Mach Number.....	158
10.3	Winds and temperature in the stratosphere	159
10.4	Supersonic flight — a summary of natural hazards in the troposphere and lower stratosphere	160
10.5	Flying conditions — a summary	163
10.6	Design of aerodromes.....	164
10.7	Meteorology for helicopter operations	166
10.8	Radio meteorology	168
10.9	Optical effects.....	171

PART II

METEOROLOGICAL OBSERVATIONS

Chapter 11

SURFACE OBSERVATIONS

11.1	Observations in general	177
11.2	Pressure	177
11.3	Temperature.....	180
11.4	Humidity.....	182
11.5	Wind	183
11.6	Cloud	185
11.7	Visibility	200

11.8	Precipitation.....	201
11.9	Weather	202
11.10	Other elements.....	203
11.11	Automatic weather stations	204

Chapter 12

UPPER-AIR OBSERVATIONS

12.1	Introduction	205
12.2	Balloon observations	205
12.3	Aircraft observations	207

Chapter 13

OBSERVATIONS USING REMOTE SENSING

13.1	radar information.....	216
13.2	Atmospherics.....	218
13.3	Satellite meteorology.....	218
13.4	Measurements from satellites.....	222
13.5	Other techniques.....	224

Chapter 14

COLLECTION AND CHARTING OF OBSERVATIONS

14.1	International cooperation.....	225
14.2	Coding of surface observations	227
14.3	Transmission of observations.....	227
14.4	Preparation of surface charts	228
14.5	Handling and display of other data.....	229

PART III

SYNOPTIC METEOROLOGY

Chapter 15

COLLECTION AND CHARTING OF OBSERVATIONS

15.1	Introduction	233
15.2	Air masses	233
15.3	Main frontal zones.....	237
15.4	Some general properties of fronts	238

Chapter 16

FRONTAL DEPRESSIONS

16.1	Formation of a frontal depression	244
16.2	Warm front	246

16.3	Cold front	247
16.4	Occlusion.....	248
16.5	Summary of frontal characteristics.....	249
16.6	General distribution of weather in a frontal depression	250
16.7	Families of frontal depressions.....	252
16.8	Upper winds over frontal depressions	253
16.9	Flight through frontal depressions.....	255

Chapter 17

OTHER DEPRESSIONS

17.1	Causes of depressions.....	258
17.2	Secondary depressions	258
17.3	Orographic depressions	260
17.4	Thermal depressions.....	262
17.5	Cold air lows	263
17.6	Tropical cyclones	263
17.7	Tornadoes	268
17.8	Waterspouts	268

Chapter 18

ANTICYCLONES

18.1	Types of anticyclone	269
18.2	General properties of anticyclones	269
18.3	Cold anticyclones	269
18.4	Warm anticyclones	271
18.5	Ridge of high pressure.....	272
18.6	Col	272

Chapter 19

ELEMENTS OF FORECASTING

19.1	Introduction	274
19.2	Analysis of the surface chart	275
19.3	Analysis of upper-air charts	278
19.4	Preparation of forecast surface charts	279
19.5	Preparation of forecast upper-air charts	287
19.6	Numerical weather prediction (NWP)	288
19.7	Preparing the forecast	293
19.8	Area, route and flight forecasts	294
19.9	Local and aerodrome forecasts	298
19.10	Forecasting in the tropics	300

PART IV

GENERAL CIRCULATION AND WORLD CLIMATE

Chapter 20

GENERAL CIRCULATION AND WORLD CLIMATE

20.1	Climatology and the aviator	309
20.2	The general circulation	309
20.3	Climatic zones	317
20.4	The climatology of some air routes	319
20.5	Using climatological data	328

PART V

METEOROLOGICAL INFORMATION FOR AVIATION

Chapter 21

METEOROLOGICAL INFORMATION FOR AVIATION

21.1	International aspects	339
21.2	United Kingdom arrangements	339
21.3	Site-specific forecasts and ‘actuals’	342
21.4	In-flight information	343
21.5	User cooperation	345

Appendix I

DERIVATION OF SOME FORMULAE INTRODUCED IN THE TEXT

Characteristic gas equation	346
Pressure and height	346
Adiabatic relations	347
Potential temperature	349
Dry adiabatic lapse rate	349
Entropy	350
Humidity mixing ratio and dew-point	352
Coriolis force	352

Appendix II

Conversion tables	354
-------------------------	-----

Annex

Guidance on the decoding of a SYNOP message	360
Guidance on the decoding of a METAR message	362
Aerodrome actual weather — METAR and SPECI decode	368
Aerodrome forecast — TAF decode	369

Form 216— explanatory notes for Form 215 — chart of forecast weather below 15 000 ft.....	370
Example Form 214 — fixed-time chart of upper winds and temperature	372
Example Form 215 — Fixed-time chart of weather below 15 000 ft.....	373
Example of gliding forecast	374
Example of ballooning forecast.....	375
Example forecast significant weather/tropopause/maximum wind chart: European (EUR) area — FL100 to FL450	376
Example forecast significant weather/tropopause/maximum wind chart: North Atlantic (NAT) area — FL250 to FL630	377
Example forecast significant weather/tropopause/maximum wind chart: Middle and Far East (MID) area — FL250 to FL450.....	378
Example forecast significant weather/tropopause/maximum wind chart: Africa (AFI) area — above FL250	379
Example forecast significant weather/tropopause/maximum wind chart: Caribbean and South America (CAR/SAM) area — above FL250	380
Example EUR forecast upper wind and temperature chart — FL100.....	381
Example NAT forecast upper wind and temperature chart — FL300.....	382
Example NAT forecast upper wind and temperature chart — FL300.....	382
Example MID forecast upper wind and temperature chart — FL340.....	383
Example AFI/CAR/SAM forecast upper wind and temperature chart — FL390.....	384
Plotted synoptic chart example, 1: March, 1200 UTC; shallow secondary wave depression on cold front crossing England and Wales.	385
Plotted synoptic chart example, 2: April, 0600 UTC; intense frontal depression over England with arctic air mass moving into Scotland.....	386
Plotted synoptic chart example, 3: November, 0600 UTC; frontal depression over northern France and deeper non-frontal depression to the west of Ireland.	387
Plotted synoptic chart example, 4: August, 0600 UTC; occluding fronts moving across British Isles. Evidence of medium-level instability above col over Low Countries.....	388
Plotted synoptic chart example, 5: January, 0600 UTC; polar continental air mass moving into the British Isles.....	389
Tephigram (blank).....	390
Index	391