



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
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Attachment 7 – Delta Air Lines Airway Manual [Excerpts]

OPERATIONAL FACTORS

DCA19CA091

Weather **Hazardous Weather**

Chapter 6: WX

Hazardous Weather Avoidance

Delta Meteorology produces a combination of textual and graphical weather products.

The Turbulence Plot System, or TP System, is the primary method for weather hazard avoidance. The system includes four components:

- Communication capabilities (both manual and automated/text and graphics)
- Avoidance policies & procedures (implemented jointly by pilots & dispatchers)
- TPs generated by Delta Meteorology
- System familiarization by pilots as well as meteorology producers and other users.

TP messages are issued for weather conditions and reports that are potentially hazardous to aviation. These hazards include:

- Clear air turbulence
- Mountain wave activity
- Thunderstorm activity
- Tropical systems
- Windshear
- Volcanic ash
- Icing
- Significant ozone
- Space weather
- Any other weather conditions which warrant alerting flight crews

TP messages and graphical weather depictions are used by dispatchers to develop a flight plan and by flight crews for preflight weather hazard awareness. Additionally, they support a pilot's enroute weather hazard monitoring.

Hazard Familiarization

Familiarization with weather hazards affecting the route of flight must be accomplished both preflight and enroute. Coordination with the cabin crew should be completed per the FOM.

The preferred method of pilot familiarization with weather hazards affecting the route of flight is using the TP display on the Flight Weather Viewer (FWV) application. If TPs on the FWV are not available, the following alternative methods are available:

During Preflight

- For all domestic flights, including Mexico, the Caribbean, and Canada (excluding Alaska and Hawaii), access the Delta Weather website and view the graphical display and text of all current TP messages along the route of flight.
- For Alaska, Hawaii, and all international flights (excluding Mexico, the Caribbean, and Canada), printouts of the following documents will be included in the preflight paperwork supplied by station personnel. Pilots are responsible for printing when departing a pilot base:
 - Current graphical and text TPs, and
 - Upper air depictions.

Enroute

- For all flights, manual plotting of TP messages may be accomplished using TP Charts, the FMC, or an orientation chart.
- For operations within the contiguous US, if plotting is not possible, use the VORs listed on the first line of Section 2 of the main body of the TP messages to produce a mental picture of the location of the hazard.

TP Messages

Delta Meteorology issues TP messages for all possible weather related hazards. There are three types of TP messages.

- **ADVISORY:** Indicates that a hazard exists (or has the potential to develop) that is below a specified criteria for that hazard. Avoidance is not required either during pre-flight by Flight Control or enroute by crews.
- **ALERT:** Indicates that a hazard exists (or has the potential to develop) that has reached a specified criteria and avoidance or action is recommended.
- **AVOID:** Indicates that a hazard exists (or has the potential to develop) that has reached or exceeded a specified criteria and avoidance or action is required.

Audible ACARS “chimes” are only enabled for “Avoid TPs;” and are inhibited for all others.

Auto-TP Uplinks

TP messages are automatically uplinked via ACARS during certain phases of flight. Only TPs that directly intersect the aircraft's flight path are uplinked.

Pre-Flight

Auto-TP uplinks are inhibited on the ground and become active at Off + 15. All applicable TPs will be delivered to the crew and are included in the Flight Plan Weather Briefing. Any new TPs are issued as part of the Updated Weather Briefing.

Enroute

Only TPs that directly intersect the aircraft's flight path are uplinked. TPs are sent 60 minutes prior to entry into the TP area. If a TP is issued after the Updated Weather Briefing and the aircraft is within 60 minutes of entry, the uplink will occur at Top of Climb (TOC). All TP uplinks are based upon the flight plan route (± 0 NM) and do not incorporate route changes, direct routing, or deviations unless the dispatcher updates the route in the flight planning system. Off course deviations require reference to the FWV to determine if any TPs are present along the intended route. If unable to reference the FWV, pilots should contact their dispatcher.

Auto-TP uplinks are inhibited 20 minutes prior to the estimated On time.

Clear Air Turbulence TP Messages

The threshold for clear air turbulence TP issuance is light to occasional moderate. These TPs are issued as either avoid, alert, or advisory.

Thunderstorm TP Messages

Significant turbulence can be associated with convection in areas of clouds and radar returns but also in the clear air which is not immediately in the vicinity of clouds or strong radar reflectivity returns.

Thunderstorms TPs describe current observed activity and are normally issued for areas or lines or occasionally for significant cells. In the contiguous US, where ground based weather radar is readily available, coverage is described in tenths. The minimum threshold usually used for issuance of thunderstorm area TPs in the lower 48 of the US is 4/10 coverage. For international and oceanic areas where weather satellite info is used as the main source, current observed activity is described as FEW, SCT (scattered), BKN (broken), or SOLID and minimum issuance threshold is usually SCT. In all cases the thunderstorm TP is issued as an ALERT TP. Because thunderstorms change rapidly, usually are less than solid coverage, and thunderstorm TPs only report the current location of activity, avoidance of the entire thunderstorm TP is not normally expected nor operationally feasible.

Turbulence Reporting Criteria

INTENSITY	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT
Light	LIGHT TURBULENCE: Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude. LIGHT CHOP: Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	MODERATE TURBULENCE: Turbulence that causes changes in altitude and/or attitude, but with the aircraft remaining in positive control at all times. Usually causes variations in indicated airspeed. MODERATE CHOP: Turbulence that causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	SEVERE TURBULENCE: Turbulence that causes large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	EXTREME TURBULENCE: Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
	FREQUENCY: 1. Occasional 2. Intermittent 3. Continuous	DEFINITION: Less than 1/3 of the time Occurring 1/3 to 2/3 of the time Occurring more than 2/3 of the time

Note: An encounter with severe or extreme turbulence requires a logbook write up and special aircraft structural inspection. Refer to FOM, Accidents, Incidents, & Irregularities, Operational Irregularities.

Clear Air Turbulence Types

Clear air turbulence (CAT) is defined as turbulence that is not associated with convective clouds, and can exist during both the climb/descent phase and the enroute phase of flight. Clouds may be observed in the vicinity of CAT.

Tropopause

The tropopause marks the boundary between the troposphere and stratosphere. Over the tropics the tropopause is usually found at 50,000' to 60,000' and slope to 25,000' to 30,000' near the poles. Awareness regarding the height of the tropopause is important during any clear air turbulence encounter, no matter what the cause. When turbulence associated with tropopause does occur, it can be the result of a variety of factors, including:

- Rapid jet stream movement
- Sharp ridge lines
- Atmospheric patterns, including strong vertical and/or directional shears, which produce waves along the tropopause boundary (sometimes manifested as transverse bands in high clouds on a satellite photo).

In most cases, the most significant turbulence will be encountered in a layer 2000' thick, extending 1000' either side of the tropopause boundary on the warm side of the jet core.

Upper Front

The tropopause usually does not extend in an unbroken line from the tropics to the poles. Often a break or sharp dip will be found in the mid-latitudes. This break, called the upper front, is caused by an extension of a surface front into the upper troposphere. At this break, a jet stream will be found. The upper front is a boundary, sloping under the jet core, separating air masses of different characteristics. Strong vertical and horizontal windshear is present across an upper front. Moderate or greater turbulence can be expected across an upper front when the horizontal and/or vertical windshear exceeds certain values. Light/moderate turbulence can also occur across an upper front at altitudes surrounding the moderate or greater turbulence, and when horizontal and vertical windshear are above certain values.

Front/Tropopause

Turbulence can occur at two different altitudes, one due to an upper front and the other due to the tropopause. The upper front turbulence is found below the jet stream at lower altitudes. The turbulence at higher altitudes is above the jet stream and associated with the tropopause.

Trough

Not all troughs are turbulent. There are several factors which determine whether a trough will be turbulent. Any combination of the following factors can increase the risk and/or intensity of turbulence:

- Magnitude of the wind direction change across the trough
- Magnitude of the vertical directional windshear across the trough
- Strength of wind speeds near the trough
- Magnitude of temperature field out of phase with wind flow
- Speed of lateral movement of trough

The most intense turbulence will usually be encountered in a layer 1000' above to 4000' below the tropopause. However, the vertical extent of trough line turbulence can vary greatly. Generally, turbulence associated with a trough line is 200 NM wide, 100 NM either side of the line depicted in the TP message. In troughs where the wind pattern and the temperature pattern are out of phase, an area of moderate or greater turbulence may extend from the trough to 200 NM or more upstream. In these cases the extent of the turbulence area will be clearly stated in the TP message.

Other Turbulence

When turbulent conditions cannot be attributed to one of the three above CAT causes (tropopause, upper front, trough line), a general turbulence area TP may be issued. Other causes of CAT include anti-cyclonic curvature in a ridge, strong divergence, and thermal instability. In addition, this type of TP is used to indicate turbulence associated with wave action in areas where predetermined wave areas have not been identified (i.e. Greenland). More details regarding this are contained within the Mountain Wave section.

Low Level Station Turbulence (Climb and Descent)

Turbulence found primarily below FL180 will be issued as station or airport TPs. Low level turbulence can be caused by wind flowing over natural or man-made features (rotors), turbulence associated within and above rapidly moving rain or snow showers, a low-level jet stream or a warm front that causes windshear during climb and descent. Station TP messages are used to describe turbulence associated with Turnagain Arm near Anchorage, Santa Ana rotor turbulence in southern California, and PVR and SJD rotor turbulence in Mexico. They are also used to describe rotor turbulence associated with mountain wave activity. For more information on rotor turbulence, see the Mountain Wave section in this chapter.