Rec'd via email (C.N. via C.A.)
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November 19, 2004

Mr. Harris M. Rosen, Esq.
Florida Power & Light Company
Environmental Services Department
700 Universe Blvd.
Juno Beach, Florida 33408

Re: Blythe Power Plant Turbulence

Dear Mr. Rosen:

Enclosed is my report on the Blythe Power Plant Turbulence issue. I have also enclosed a CD containing the photos I took during the flight test at Blythe. I apologize for the blurriness of the first few photos; they can only be attributed to operator error.

Please let me know if you need anything else.

Sincerely,

Robert C. Winn, Ph.D., P.E.
Principal Engineer and Director of Colorado Operations

35552

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Analysis of Turbulence Over the FPL Blythe Power Plant

Submitted To:

Mr. Harris M. Rosen, Esq.
Florida Power & Light Company
Environmental Services Department
700 Universe Blvd.
Juno Beach, Florida 33408

Submitted by:

Robert C. Winn, Ph.D., P.E.
Principal Engineer
Director of Colorado Operations

PE License Expiration: 12/31/2005

Reviewed by:

Steven L. Morris, Ph.D., P.E. (Texas)
Senior Consultant

Date of Report: November 19, 2004
ESI File # 17667C

INTRODUCTION

Engineering Systems Inc. (ESI) was retained to assist in the analysis of turbulence reported over the FPL Blythe Energy Power Plant. Several pilots have reported turbulence when flying an approach to Runway 26 at the Blythe Airport. The turbulence was experienced when the airplanes were flying over the cooling towers at the power plant. ESI was asked to evaluate the turbulence and assess the potential hazard associated with flight over the power plant.

BACKGROUND

There are four runways at the Blythe Airport, Runways 08-26 and 01-19 as shown in Figures 1 and 2. The Blythe Energy Power Plant is located approximately 1 mile east of the approach end of Runway 26. The plant's four cooling towers are oriented east-west and approximately 50 feet north of the centerline of Runway 26 as shown in Figure 3.

There are no published limitations on visual traffic patterns except to avoid overflight of a residential area to the south of the airport. There are three certified instrument approaches to the Blythe Airport; the approach plates of the approaches to Runway 26 are shown in Figures 1 and 2.

Since late 2002, there have been five documented reports of moderate to extreme turbulence over the Blythe Energy Power Plant. All five pilots were flying approaches to Runway 26 at the Blythe Airport and reported turbulence levels that ranged from moderate to extreme. The airplanes being flown in the reports of extreme turbulence were "Cessna/single" engine airplanes. Reports of moderate to severe turbulence were reported by pilots flying a Beechcraft twin and a Lear two engine business jet.

ANALYSIS

A flight test was flown at the Blythe Airport on 3 November 2004. A Piper Aztec, a two engine propeller airplane, was used as the test airplane. The Aztec weighed approximately 4300 pounds at the time of the flight test. Each event, except the approach to final landing, was flown at 120 knots indicated airspeed. Vertical accelerations were measured in G's by two self-contained accelerometers and maximum and minimum accelerations for each event were recorded. The accelerometers were not attached to the airframe; they were held against horizontal surfaces by passengers (myself and a FPL employee). The weather conditions at the time of the flight were cool, calm winds, and only occasional light natural turbulence.

The flight test consisted of flights over the power plant a variety of altitudes. The lowest altitude at which there was any indication of turbulence from the power plant was 1000 feet above the ground (1000 feet AGL). In general, the turbulence as inferred by the measured accelerations, increased as altitude decreased. The maximum positive

acceleration measured was 1.9 G's and the minimum was 0.0 G's. By comparison, accelerations measured while the airplane was maneuvering prior to a pass over the plant were 1.3 and 0.8 G's. Because the accelerometers were not attached to the airframe, the minimum values recorded were most likely influenced by the passengers holding the instruments; therefore, the correct values for the minimum accelerations are most likely higher than what was recorded. A complete summary of the results of the flight test is presented in Figure 4.

The reporting of turbulence by pilots is covered in the Airman's Information Manual. The categories of turbulence intensity according to the FAA are shown in Figure 5. Using these criteria, the maximum turbulence encountered during the flight test was Intermittent Moderate Chop. It should also be noted that the altitude over the cooling towers during the flight test was as low as 150 feet AGL, which is significantly lower than the 300-350 feet one would expect if an airplane was flying a normal approach. The general characteristics of the turbulence encounters was an abrupt increase in vertical acceleration as the plume was initially entered, followed by light chop while in the plume, and finally a reduction vertical acceleration to something less than one as the airplane left the plume.

The duration of each exposure was limited to the time the airplane was directly over the cooling tower or stack. The airplane was flying at 120 knots indicated. This corresponded to a ground speed of approximately 210 feet per second. If an airplane flies the full length of the cooling towers array, the duration of exposure is approximately two seconds. For an airplane with an approach speed of 70 mph, the time of exposure is increased to approximately four seconds.

Aircraft experience turbulence on a daily basis. In the vast majority of cases, that turbulence is a nuisance at worst. Turbulence encounters can become dangerous under a certain set of circumstances. First, if an airplane at high airspeed encounters severe turbulence, structural damage to the airplane can occur. Second, if an airplane is at low airspeed and altitude encounters turbulence that results in a significant loss of airspeed, stall and/or a hazardous sink rate can occur. Finally, if an airplane is flying in the clouds, called instrument meteorological conditions (IMC), and encounters sustained severe turbulence, the pilot is more likely to experience spatial disorientation, which can have catastrophic results with an inexperienced pilot. Fortunately, none of these conditions exist in the present case.

1. When an airplane encounters turbulence, the wing undergoes rapid and sometimes large changes in angle of attack. The lift that a wing produces is directly related to angle of attack. The excursions in load factor (G's), both positive and negative, that are experienced by an airplane in turbulence are a result of these changes in angle of attack. If an airplane is flying below what is referred to as the maneuver speed, it cannot produce enough lift to damage the airplane. At the maneuver speed, the wing will stall before it can produce damaging lift. Any airplane flying on final approach is well below maneuver speed.

2. Significant loss of airspeed when close to the ground can certainly be dangerous, and that can happen in certain types of turbulence, but this is not the situation at Blythe. The loss of airspeed occurs when an airplane flies into a shear that rapidly changes the wind from a headwind to a tail wind. Loss of airspeed does not occur when an airplane encounters an updraft. Any turbulence that might be encountered when flying over the Blythe Energy facility would be related to an updraft, not a horizontal shear. The updraft could increase the angle of attack to beyond the stalling angle of attack, however, that same updraft acts on the tail of the airplane and causes the nose to pitch down which reduces the angle of attack. The natural stability of the airplane immediately starts to return the airplane to an angle of attack to well below stall. Therefore, the result of an encounter with an updraft is an initial increase in lift and a corresponding increase in altitude, followed by an immediate decrease in lift. Then when the airplane leaves the updraft, the angle of attack will rapidly decrease with a corresponding tendency for the airplane to pitch up. There will be a net increase in altitude of the airplane.

3. Flying on instruments in IMC is a greater challenge than flying with full visual reference to the outside. That is why training and pilot rating is required to legally fly in IMC. That training becomes absolutely essential when flying an instrument approach in bad weather. If that approach is flown in turbulence as well, the challenge can be too much for some pilots. There are three instrument approaches to the Blythe Airport, two of which can be flown to Runway 26. The VOR-DME RWY 26 approach has the lowest minimums; the cloud bases have to be at least 400 feet above the ground for a legal approach to be flown to the Blythe Airport. That means that an approach flown in the worst weather will have the airplane break out of the clouds before it gets to the power plant. In addition, all of the approaches to Runway 26 have the airplane coming in to the north of the power plant. No airplane should ever fly over the power plant on an approach while in the clouds. Encountering some turbulence with the airport in sight can be surprising and perhaps annoying, but it is not hazardous.

The Blythe Airport has four runways: 26, 08, 17, and 35. Runways 17-35 are 5820 feet long, and Runways 26-08 are 6562 feet long. All four runways are suitable for almost all private airplanes. If the winds are nearly calm (the conditions that are the most conducive to turbulence over the power plant), any one of the four runways can be used. If the winds are strong out of the west, Runway 26 may be the only reasonable option for a pilot, but the thermal plumes will be blown to the west and rapidly dispersed. The only reports of turbulence on final were on days with very light or no winds.

An airplane flying over the cooling towers at the Blythe Energy Power Plant at low altitude will experience some turbulence; however, this turbulence is short lived and not hazardous. The short duration of the encounter and the airplane's natural stability will dictate that the encounter will not be hazardous in and of itself. An inexperienced and low-skill pilot could be startled by such a turbulence encounter, but as long as this pilot does not panic and freeze on the controls, the airplane will ride through this turbulence safely due to its inertial and inherent stability.

OPINIONS

1. Low altitude flight over the cooling towers in near calm wind conditions will result in a short duration encounter with some turbulence up to a level of moderate.

2. The updraft from the power plant that causes the potential turbulence will increase an airplane's altitude and/or airspeed; it will not cause a dangerous decrease in altitude.

3. An encounter with this turbulence will not result in structural damage to the airplane.

4. An airplane accurately flying a published instrument approach to Blythe Airport should never encounter turbulence from the power plant while in instrument meteorological conditions.

5. The turbulence encountered by an airplane flying over the power plant is similar to that encountered during normal summer flying in the Blythe area.

6. An inexperienced and low skill pilot who is startled by a turbulence encounter could panic, but the natural stability of an airplane will prevent a hazardous condition from occurring. Only inappropriate pilot behavior could make encounter hazardous.

I reserve the right to amend these opinions if additional relevant information becomes available.

RECOMMENDATIONS

1. AirNav.com has the following announcement in the "Additional Remarks" section for the Blythe Airport: "Power plant 1 mile east of arpt producing thermal plumes. Avoid low altitude direct overflight of the power plant." This is an appropriate announcement to pilots flying into Blythe Airport, but should be expanded to suggest that Runway 26 not be used in calm wind conditions. The above statements should be included in a NOTAM, but ultimately incorporated into the appropriate government documents describing the Blythe Airport.

2. The visual traffic patterns to Runway 26 should be restricted to north of the runway only. This will limit the exposure of airplanes to power plant as well as prevent any overflight of the residential area south of the airport.

[End of Report]

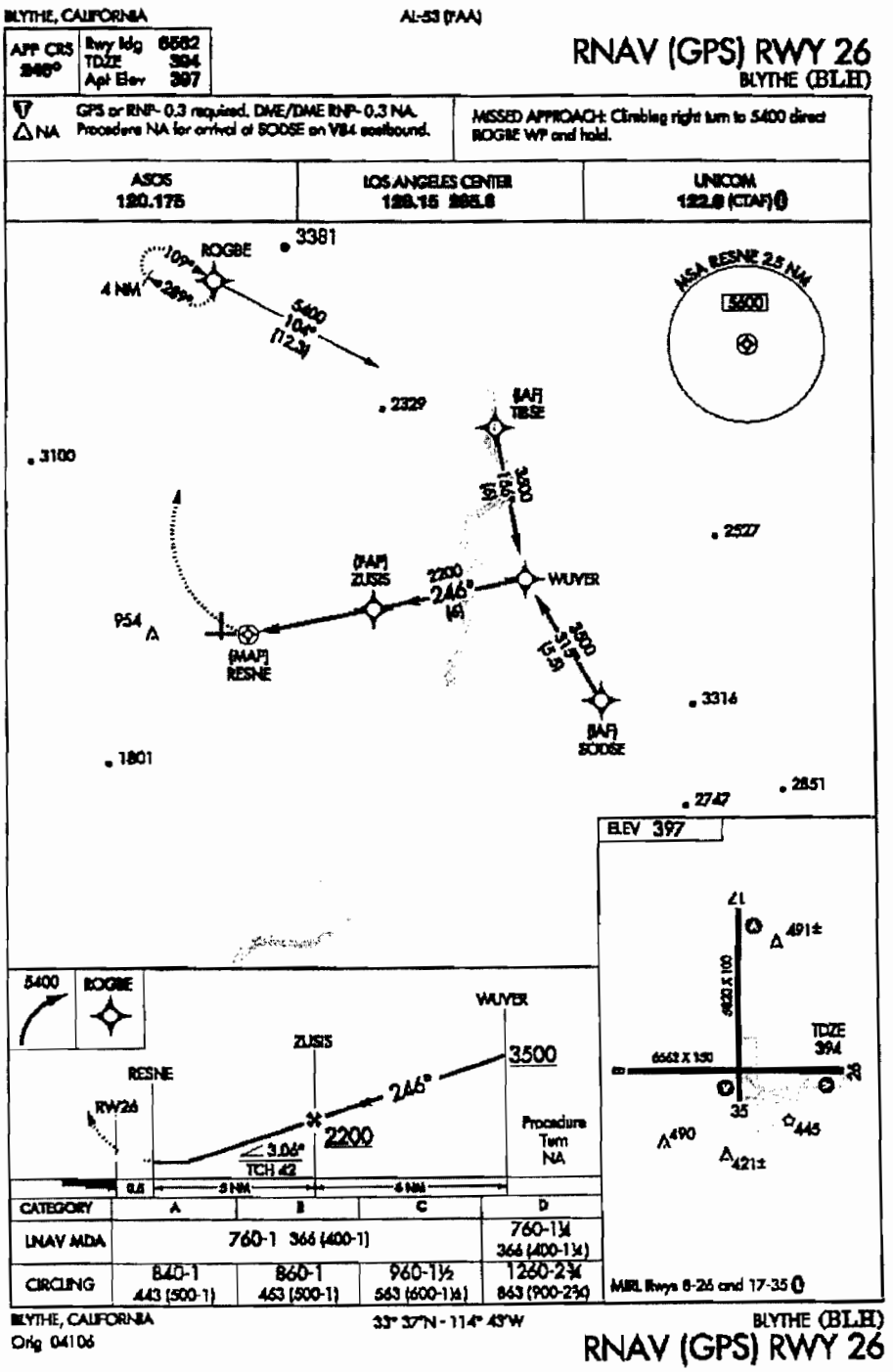


Figure 1 RNAV Approach to Runway 26

ESI

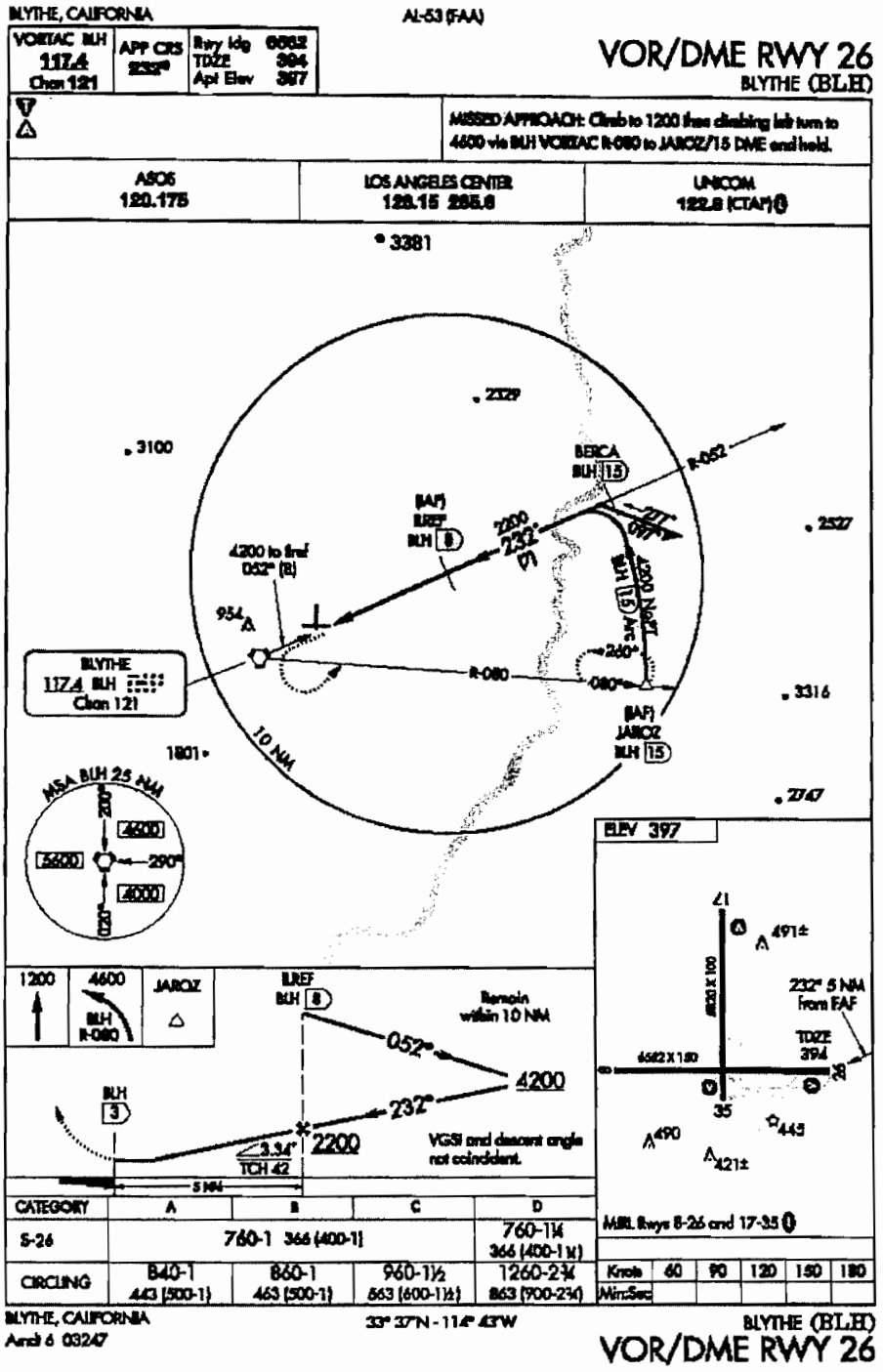


Figure 2. VOR/DME Approach to Runway 26

ESI

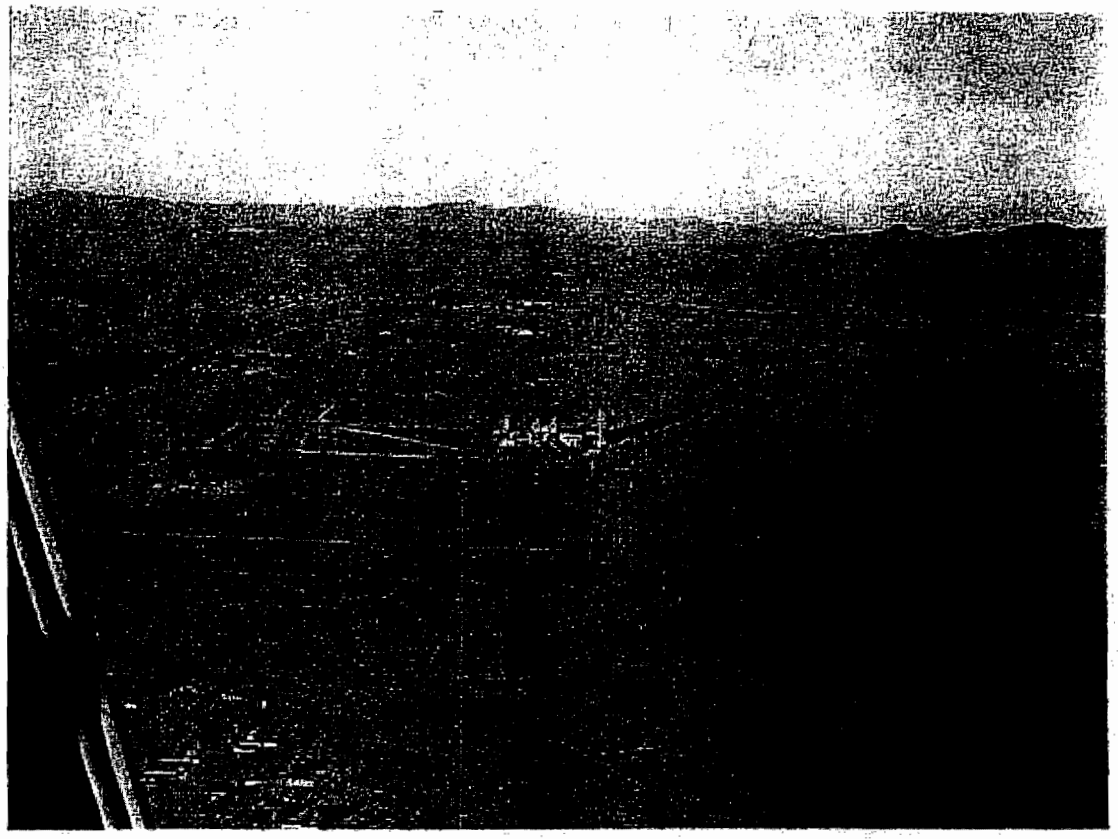


Figure 3. Orientation of Cooling Towers Relative to Runway

ESI File # 17667C - Blythe Power Plant - Airport Investigation
Flight Test - 3 Nov 04

Flown in an Aztec
Weight = 4300 lbs

Time = 620 PST
Temp = 7 C
Alt = 30.15 in Hg
Wind = Calm
Speed = 120 kt

North to South		ESI Max Gs	ESI Min Gs	FPL Max Gs	FPL Min Gs	
3000	ft AGL	Smooth				
2000	ft AGL	Smooth				
1000	ft AGL	1.3				
750	ft AGL	1.6	0.6	1.5	0.6	
500	ft AGL	1.8	0.2	1.9	0.4	
400	ft AGL	1.6	0.5	1.6	0.5	
300	ft AGL	1.7	0.5	1.7	0.5	

Note: Over Desert Gs ranged from 1.3 to 0.8

East to West		ESI Max Gs	ESI Min Gs	FPL Max Gs	FPL Min Gs	
200	ft AGL	1.3	0.1	1.5	0	Over Cooling Tower
150	ft AGL	1.8	0.3	1.9	0.2	Over Cooling Tower
GS-300	ft AGL	1.5	0.4	1.5	0.4	Over Cooling Tower
GS-300	ft AGL	1.8	0.5	1.8	0.5	Over Stack (Turbulence was very brief, ~0.3 sec)

Time = 714 PST
Temp = 9 C
Alt = 30.15 in Hg
Wind = Calm
Speed = 120 kt

East to West		ESI Max Gs	ESI Min Gs	FPL Max Gs	FPL Min Gs	
GS	ft AGL	1.3	0.7	1.3	0.7	On Runway Centerline - 140 MW

Note: Over Desert Gs ranged from 1.2 to 0.9

Time = 726 PST
Temp = 9 C
Alt = 30.15 in Hg
Wind = 270/03
Speed = 120 kt

East to West		ESI Max Gs	ESI Min Gs	FPL Max Gs	FPL Min Gs	
200	ft AGL	1.6	0.5	1.7	0.5	Over Cooling Tower - 146 MW
150	ft AGL	1.5	0.7	1.6	0.7	Over Cooling Tower - 146 MW
350	ft AGL	1.4	0.4	1.4	0.4	On Final - 85 kt

Figure 4. Summary of Flight Test Results

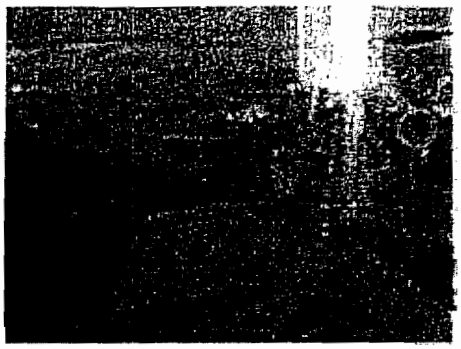
Turbulence Reporting Criteria Table

Intensity	Aircraft Reaction	Reaction Inside Aircraft	Reporting Term-Definition
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence;** [1] or Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop.**	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.	Occasional-Less than $^1/_3$ of the time. Intermittent-$^1/_3$ to $^2/_3$. Continuous-More than $^2/_3$.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as **Moderate Turbulence;** [1] or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as **Moderate Chop.**[1]	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.	**NOTE** 1. Pilots should report location(s), time (UTC), intensity, whether in or near clouds, altitude, type of aircraft and, when applicable, duration of turbulence. 2. Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report **as Severe Turbulence.** [1]	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food Service and walking are impossible.	**EXAMPLES:** a. Over Omaha. 1232Z, Moderate Turbulence, in cloud, Flight Level 310, B707.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as **Extreme Turbulence.** [1]		b. From 50 miles south of Albuquerque to 30 miles north of Phoenix, 1210Z to 1250Z, occasional Moderate Chop, Flight Level 330, DC8.

[1] High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity, or light or moderate chop.

Figure 5. FAA Turbulence Reporting Criteria

Job #17667C (ESI-CO) taken on 03 Nov, 04 by RCW



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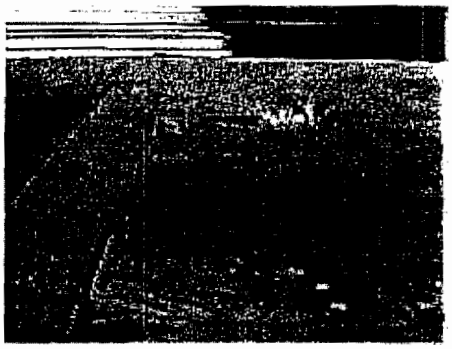

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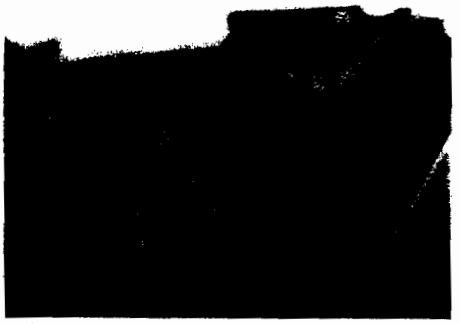

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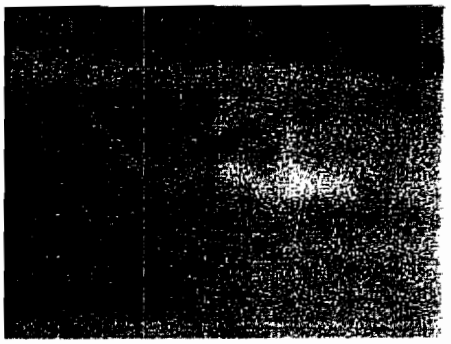

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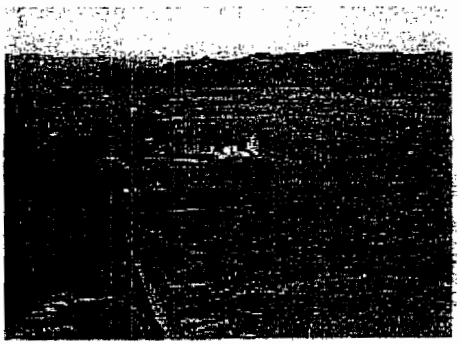

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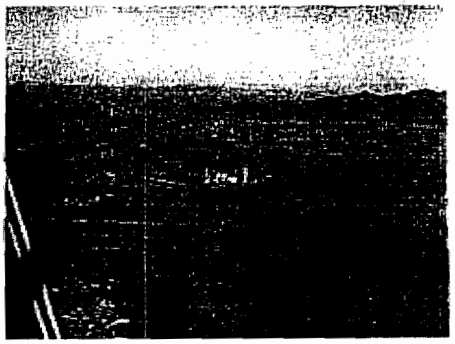

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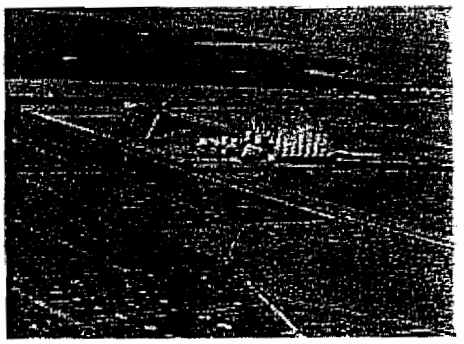

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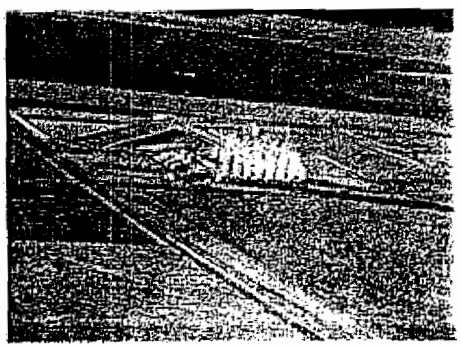

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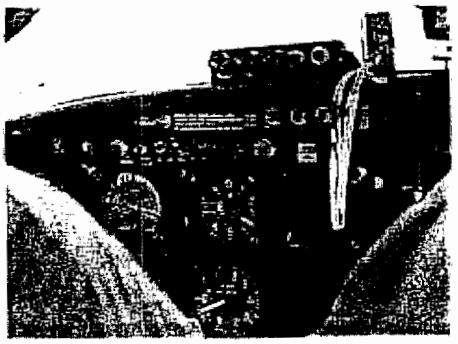

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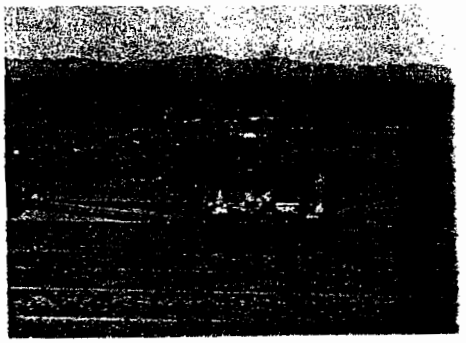

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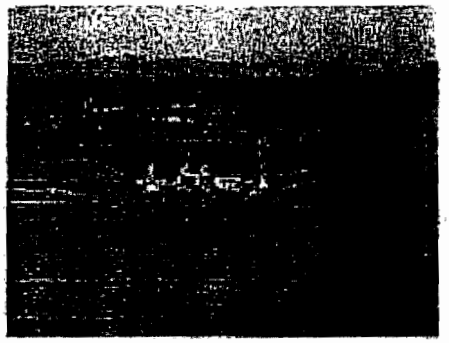

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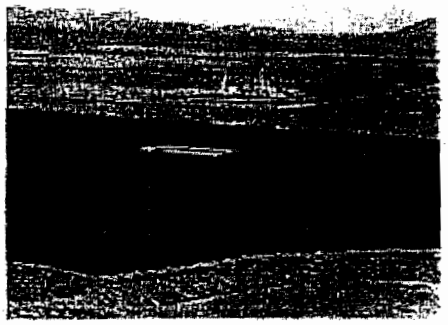

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