



# Operating Boeing 737-NG with Cold-Soaked Fuel Frost

**Philip Adrian / Julie Brightwell**  
**15 October 2013**

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# Cold-Soaked Fuel Frost (CSFF) Overview

## ■ What is it?

- Cold-soaked fuel from flight + humid airport = inspar wing frost
- Similar to frost that can form on the outside of a beer glass
- FAA 14 CFR Part 121 rules do not currently allow dispatch w/ CSFF, but EASA CAT.OP.MPA.250 (b) & Transport Canada allow operations

## ■ How it forms:

- Usually forms during descent through humid lower altitudes
- No issues with continued safe flight and landing after CSFF forms
- More frequent on 737NG than other models because of short turn-around and large wing fuel volume
- Common to experience CSFF in hot climates (e.g., Miami, Houston, Dallas, Los Angeles), even in the summer, where de-icing equipment is not available

## ■ Procedures to remove CSFF

- Refuel with warmer fuel
- Longer turn-around time
- Ground de-icing

# Pictures of Cold-Soaked Fuel Frost



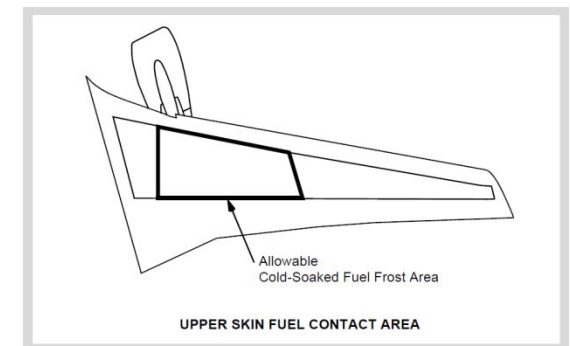
# Detailed Study of CSFF

- **Over the past year Boeing has studied CSFF in more detail**
  - **Refined frost growth prediction model**
    - **Takes into account heat profile in the fuel, heat conductivity of frost, and latent heat of water vapor condensation**
    - **Predicts frost growth over time for a wide matrix of conditions**
  - **Physical properties of cold-soaked fuel frost**
    - **CSFF is not as rough as Radiation (Hoar) frost**
    - **Leveraged data published in the refrigeration industry to understand CSFF roughness**
  - **CSFF effect on aerodynamics**
    - **Only forms in the spar box region of the wing where fuel is present, not on the ice-critical leading edges**
    - **Wind tunnel, flight test data used to set and confirm frost footprint and thickness limits that ensure insignificant impact**

**Analysis confirms that current procedure is safe and meets all certification requirements**

# Current AFM Procedure

- **EASA and Canada AFMs allow dispatch with CSFF if the following conditions are met:**
  - Frost height is less than 1/8 in (3 mm) on the lower surface
  - Frost height is less than 1/16 in (1.5 mm) on the upper surface
  - Air temperature is greater than 0°C
  - The frost must be inside the black inspar box on the wing
  - Frost growth must be close to symmetrical on both wings
  - There is no precipitation or visible moisture
- **FAA AFMs do not include CSFF procedures**
- **Renewed pressure from US and other operators to approve a simplified procedure**
  - No impact on safety
  - Significant operational opportunities (cost, schedule, environmental)



# Regulator and Customer Feedback

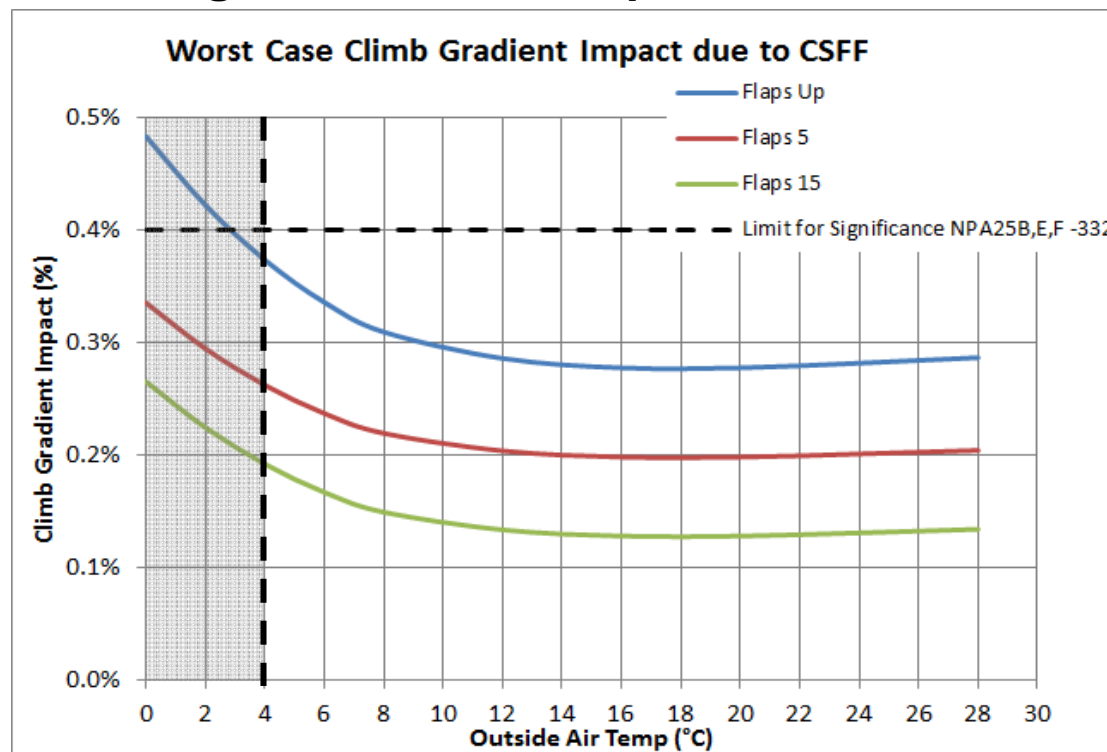
- **EASA and National Aviation Authorities have approved operations with CSFF in accordance with AFM, with emphasis on having a procedure in place for accurate frost thickness measurement**
- **Crew concerns about required accuracy of frost thickness measurement**
- **Difficult to measure frost thickness on upper wing surface**
- **Pilots will likely call for deicing if unclear about symmetry of frost**

**Boeing is proposing simplified procedure to reduce pilot workload and operational impact**



# Proposed Simplified Procedure

- Boeing has evaluated a range of environmental conditions impact on frost growth
- Near 0°C, small air temperature changes have large impact on frost thickness
- Limiting CSFF dispatch to 4°C & above eliminates all scenarios where frost could grow to an unacceptable thickness



# Proposed Simplified Procedure

## ■ Boeing proposes limiting CSFF operations to air temperature 4°C & above

- Simplifies procedure – eliminates pilot measurement entirely
- For these temperatures, worst case frost thickness has insignificant aerodynamic impact

## ■ Eliminate symmetry requirement

- Amount of wheel to compensate for the worst case CSFF asymmetry is within the lateral trim tolerances specified in the AMM
- Boeing Test Pilots concur that this amount of wheel is acceptable

### Current:

With CSFF, aircraft cannot take-off per the AFM unless the following conditions are met:

- Frost height is less than 1/8 in (3 mm) on the lower surface
- Frost height is less than 1/16 in (1.5 mm) on the upper surface
- Air temperature is greater than 0°C
- The frost must be inside the black inspar box on the wing
- Frost growth must be close to symmetrical on both wings
- There is no precipitation or visible moisture

### Proposed:

With CSFF, aircraft cannot take-off per the AFM unless the following conditions are met:

- Air temperature is 4°C or higher
- The frost must be inside the black inspar box on the wing
- There is no precipitation or visible moisture



# Future Actions

- **AFM update in work with revised limitation**
- **Anticipate AFM approval 1<sup>st</sup> quarter 2014**
- **European operators must incorporate updated AFM page on their 737NG's to take advantage of new limitation**



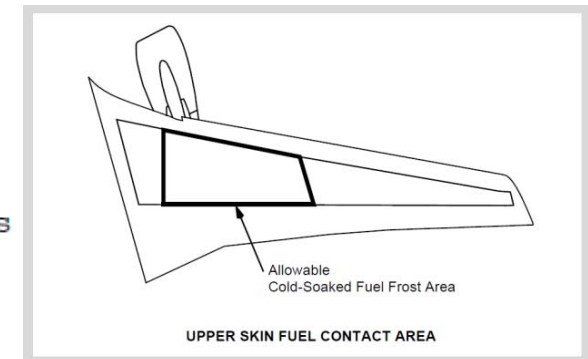
# Current AFM Procedure

## COLD SOAKED FUEL FROST

The certified performance data in this AFM is not affected if cold soaked fuel frost does not exceed the limits specified below. This finding does not constitute operational approval to conduct takeoffs with cold soaked fuel frost on the wings.

Takeoff is not permitted if:

1. There is any cold soaked fuel frost on the wings and the provisions of Boeing Service Bulletin 737-11-1125 or the production equivalent have not been incorporated.
2. The cold soaked fuel frost exceeds 1/8 inch (3 mm) in thickness on the lower wing tank surfaces.
3. There is cold soaked fuel frost on the upper wing tank surfaces:
  - (a) That exceeds 1/16 inch (1.5 mm) or
  - (b) That is not of similar extent on both wings or
  - (c) That is beyond the outer edge of the black lines defining the cold soaked fuel frost area (in accordance with Boeing Service Bulletin 737-11-1125, or the production equivalent).
4. There is cold soaked fuel frost on the upper wing tank surfaces:
  - (a) And the ambient air temperature is below freezing (0° C, 32° F) or
  - (b) There is precipitation or visible moisture (rain, snow, drizzle, or fog with less than 1 mile visibility).



# Regulatory Requirements

## ■ FAA 14 CFR 121.629(b)

- “No person may take off an aircraft when frost, ice, or snow is adhering to the wings, control surfaces, propellers, engine inlets, or other critical surfaces of the aircraft.....Takeoffs with frost under the wing in the area of the fuel tanks may be authorized by the Administrator.”

## ■ EASA CAT.OP.MPA.250 (b)

- “The commander shall only commence take-off if the aircraft is clear of any deposit that might adversely affect the performance or controllability of the aircraft, except as permitted under (a) and in accordance with the AFM.”