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1. REFERENCES

[Ref 1.] EUROCAE Minimum Operational Performance Standard for In Flight Icing Detection Systems (FIDS): ED-103A (Nov 2017)

[Ref 2.] EUROCAE Minimum Operational Performance Standard for In Flight Icing Detection Systems (FIDS): ED-103B (Under EUROCAE Revision process)

[Ref 3.] SAE Aerospace Standard for In Flight Icing Detection Systems (FIDS) AS5498A (2017-12)

[Ref 4.] SAE Aerospace Standard for In Flight Icing Detection Systems (FIDS) AS5498B (Under SAE Revision process)

[Ref 5.] FIDS RESPONSE TIME CALCULATION TOOL ED103_RESPONSE_TIME_Calculation_Tool_V4-0.xlsm

Note 1: On September 2020 a EUROCAE/SAE revision process of the ED-103A/AS5498A documents has been initiated to correct the Appendix A1 with at least three types of changes:

- **EDITORIAL**: corrections of typos in the equation (9) and in some Terms of Table 10, without impact on the Test Matrices of ED-103 Table 8 and 9 (AS5498A Table 1 and 2).
- **TECHNICAL**:
  a) to replace the Constant value (1.88 E-05) of the Thermal Diffusivity of air (αt) by the equation $\alpha t = Ka/(\rho\ cp)$. This change will have a significant impact on the resulting freezing fraction values and the FIDS Response Time and Discrimination Times in the Test Matrices of Table 8 and Table 9 (AS5498A Table 1 and 2).
  => *Impact of the error on the current ED-103 Rev A* : makes the calculation of the equipment **Response Time more conservative (more safe)** than necessary for certain environmental conditions.
  b) the Discrimination Time formula shall be changed in the spreadsheet used to generate Test Cases of Table 8 and 9. *(The Freezing Fraction corresponding to the subset of drops above the discrimination drop diameter threshold shall be used instead of the Freezing Fraction of the entire drop diameter distribution).*
  => *Impact of the error on the current ED-103 Rev A:* makes the calculation of the equipment **Discrimination Time longer than required (less safe)** for certain environmental conditions.
- **CLARIFICATION**: to specify that all calculations are considering a fixed surface temperature of 273.15 °K (Tsurf = 273.15 °K) and a barometric pressure of B=42797 Pa (Alt = 22 000 ft).

To revise the MOPS ED-103A, the EUROCAE Working Group 95 is going to be reactivated end of January 2020. The SAE AC-9C Ice Detection Panel will work jointly with the WG95 to revise the AS5498A document.

CAUTION NOTE: ED-103 / AS5498 Rev B documents are expected to be published by mid or end 2021. The tool V4.0 is anticipating the Rev B changes but until the ED-103 B and AS5498B are officially released and published, **ED-103 A and AS5498A are the only valid documents to be used**.

2. INTRODUCTION

This tool calculates the FIDS RESPONSE TIME and DISCRIMINATION TIME as specified in ED-103A / AS5498A standards (Ref 1 & Ref 3) or as anticipated in ED-103B / AS5498B standards (Ref 2 & Ref 4), see Note 1 page 1.

The Spreadsheet implements the FIDS Response Time Requirements, Matrices of test points and calculations method defined in ED-103A or B / AS5498A or B refer to:

- The FIDS Response Time Requirements of Chapter 3.4.
- The Matrices of test points of Chapter 5, which represent a minimum set of fight conditions to be used to demonstrate compliance to the Requirements of Chapter 3.

  A first TABLE (**ED-103 TABLE 8** or **AS5498 TABLE** 1) defines test points for Liquid Water (LW) Conditions.

  The second TABLE (**ED-103 TABLE 9** or **AS5498 TABLE 2**) defines test points for MIXED PHASE or GLACIATED Conditions.

  Each TABLE contains, one Matrix for AIRCRAFT application and one matrix for ROTORCRAFT application.
- The Appendix A of ED-103 / AS5498 provides the rationale to determine the FIDS Response Time Requirement and the method used to calculate the response time and Discrimination Time for any ice detection technology.

2.1. INTENT OF THE FIDS RESPONSE TIME CALCULATION TOOL

Based on ED103A or B / AS5498A or B requirements and method to calculate the FIDS response time or discrimination time, the FIDS RESPONSE TIME CALCULATION TOOL has been designed to calculate the FIDS response times and discrimination times for test conditions different from the one defined in the two TABLES of ED-103 / AS5498 (e.g. new or modified test points resulting from the equipment manufacturer analysis as recommended in section 5.2.1 of ED-103 / AS5498).

The FIDS RESPONSE TIME CALCULATION TOOL is an EXCEL based calculation tools that can be used in two different ways:

- Using the "**User's Interface**" EXCEL sheet to interactively define new test point conditions (and/or ice accretion) conditions and get the associated values of the Icing parameters (Freezing Fraction, Collection Efficiency, Ice accretion rate) and the maximum FIDS RESPONSE TIME and DISCRIMINATION TIME.

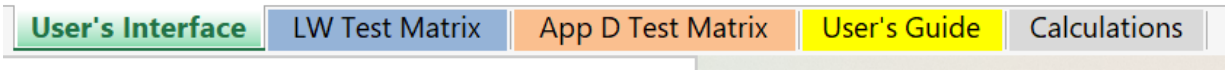
OR

- Using the "**LW Test Matrix**" or "**App D Test Matrix**" EXCEL sheets to modify the test points of the ED-103 / AS5498 test matrices or update some test conditions or add new test points and then run an EXCEL macro able to scroll each individual test points contained in the test matrix and calculate and update the matrix with the resulting values (collection efficiency, freezing fraction, response time, discrimination time, ice accretion rate etc.).

3. SPREADSHEET – STRUCTURE & CONTROLS

3.1. STRUCTURE

This Excel tool comprises 5 different sheets which are visible to the Users:



- **User's Interface** Interactive FIDS RESPONSE TIME calculation.
- **LW Test Matrix** Contains the test points of the Test Matrix for liquid water conditions (see ED-103 TABLE 8 or AS5498 TABLE 1). Test points can be modified and new test points can be added.
- **App D Test Matrix** Contains the test points of the Test Matrix for Mixed Phase or Glaciated conditions (see ED-103 TABLE 9 or AS5498 TABLE 2). Test points can be modified and new test points can be added.
- **User's Guide** User's Guide (PDF) and Help topics describing how to use the Tool.
- **Calculations** Contains the reference parameters and equations to calculate the FIDS RESPONSE TIME. The parameters cannot be modified by the Users.

In addition to the above Sheets, there is an hidden sheet "GRAPHS" which is not accessible to the Users. The GRAPHS sheet is used to display the regulatory Figures of Appendix C, Appendix O and Appendix D/P showing the SAT = f(Alt), LWC = f(MVD, SAT), TWC = f(Alt, SAT), App O Drop Diameter distribution (Refer to the DISPLAY control function here below).

3.2. SPREADSHEET CONTROL FUNCTIONS

This Excel tool comprises 6 different types of CONTROLS using dedicated Excel Macros:

- **FILE:** **User's Interface** sheet, used to SAVE or SAVE AS the file or QUIT the tool. (See Figure 1)
- **SELECT ED-103 Rev** **User's Interface** sheet, allows the User to select either ED-103 Rev A requirements or anticipate the results with ED-103 Rev B requirements. (See Figure 1)
- **DISPLAY** **User's Interface** sheet, allows the User to display the regulatory Figures of Appendix C, Appendix O and Appendix D/P showing the SAT = f(Alt), LWC = f(MVD, SAT), TWC = f(Alt, SAT), App O Drop Diameter distribution. (See Figure 1)
- **AIRCRAFT or ROTORCRAFT** **LW Test Matrix** or **App D Test Matrix** sheets, used to show either the AIRCRAFT or ROTORCRAFT test matrix. (See Figure 2)
- **UPDATE MATRIX** **LW Test Matrix** or **App D Test Matrix** sheets, used to scroll each individual test points contained in the test matrix and calculate and update the matrix with the resulting values. (See Figure 2)
- **PRINT MATRIX** **LW Test Matrix** or **App D Test Matrix** sheets, used to print the selected test matrix. (See Figure 2)

« FILE » , « DISPLAY » and « SELECT ED-103 Rev » Control Buttons

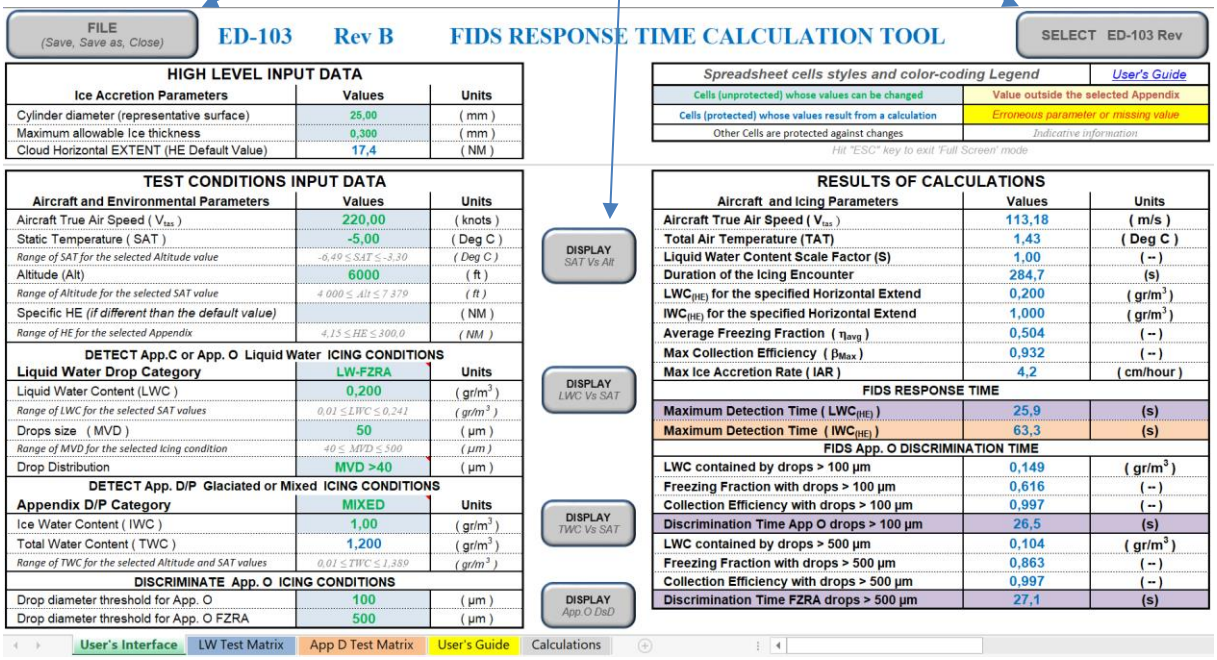


Figure 1 – CONTROL functions of the User's Interface Sheet.

« AIRCRAFT / ROTORCRAFT» Control Buttons

« UPDATE MATRIX» and "PRINT MATRIX" Control Buttons

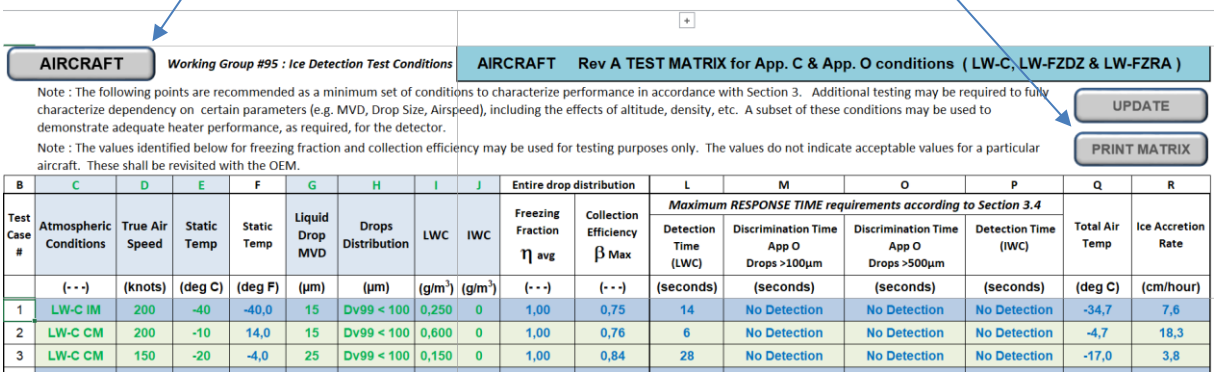


Figure 2 – CONTROL functions of the LW Test Matrix or App D Test Matrix sheets.

4. "User's Interface" Sheet

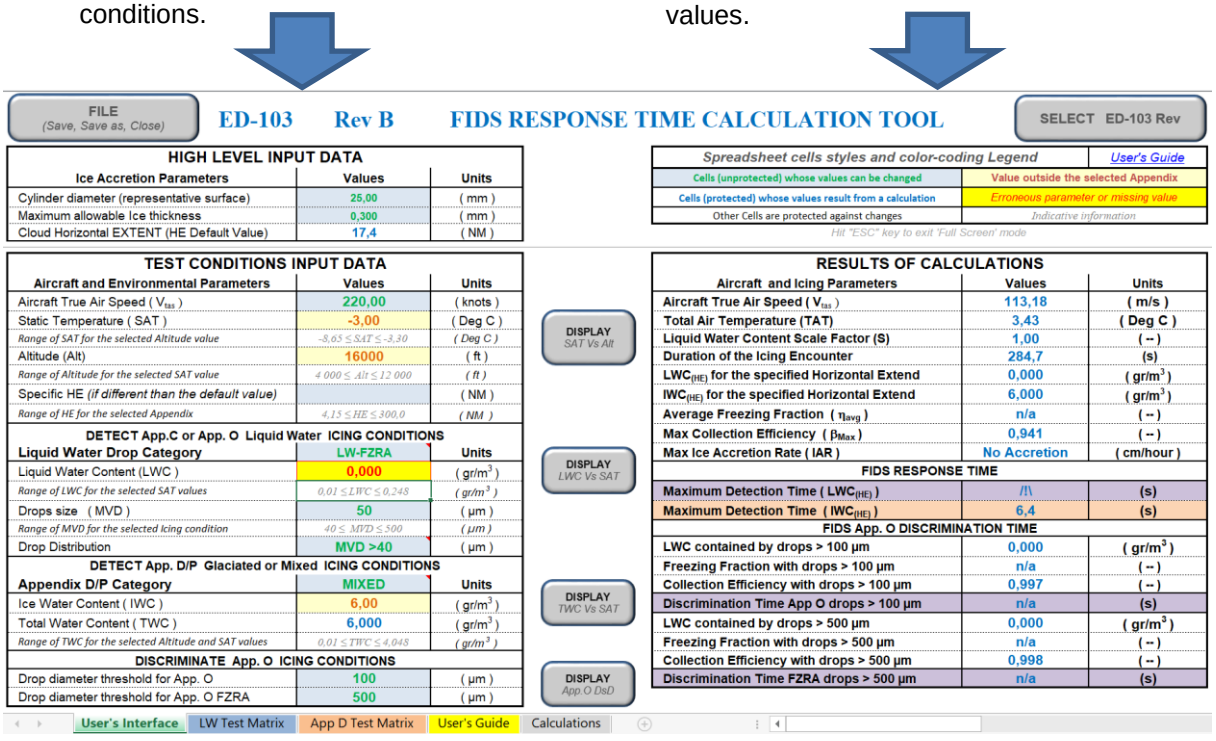
On the left side of the EXCEL sheet two **INPUT DATA TABLES** can be filled with:

- **HIGH LEVEL INPUT DATA** like :
  - the **Cylinder Diameter**, defined in ED-103 as the aircraft representative surface
  - the detectability **Ice Thickness threshold**.
  - the default value of the Cloud Horizontal Extent is provided as an indication but cannot be changed. (use the specific HE here below if you wish different HE values.).
- **TEST CONDITIONS INPUT DATA** like:
  - **Aircraft and Environmental Parameters**: Airspeed, Static Temperature, Altitude, specific Horizontal Extend (if different that the default HE here above).
  - **Detect Liquid Water Icing Conditions:** LW Drop Category, LWC, MVD, Drop Distribution.
  - **Detect App D/P Icing Conditions:** App D/P Category, IWC. The TWC value is calculated using the LWC and IWC values.
  - **Discriminate App O Icing Conditions:** Drop diameter thresholds used to discriminate App. O and FZRA from other icing conditions.

On the top of the right side of the EXCEL sheet, a "Legend" table gives indications regarding the meaning of the spreadsheet cells styles and color-codes.

A second table below, displays the **RESULTS OF CALCULATIONS** with three groups of output data:.

- **Aircraft Icing Parameters:** the Aircraft TAS in m/s, Total Temperature, LWC scale factor, duration of the icing encounter and the values of LWC and IWC values calculated from the selected HE value. Average Freezing Fraction (η_{Avg}), Max Collection Efficiency (β_{Max}), Max Ice Accretion Rate (IAR).
- **FIDS RESPONSE TIME:**
  Maximum Detection Time for Liquid Water
  Maximum Detection Time for Ice Water
- **FIDS App. O DISCRIMINATION TIME:**
  Discrimination time App. O Drops > 100µm and >500µm:
  The LWC values corresponding to the subset of drops above the 100µm or 500µm drop diameter threshold and the associated Freezing Fraction and Collection Efficiency values.



The symbol **/!\ or n/a** may appear in the RESULTS Values CELLS when erroneous input parameters are provided (e.g. LWC = 0 or wrong drop distribution).

4.1. Spreadsheet cells styles and color-coding Legend

Spreadsheet cells styles and color-coding Legend	*User's Guide*
Cells (unprotected) whose values can be changed	Value outside the selected Appendix
Cells (protected) whose values result from a calculation	*Erroneous parameter or missing value*
Other Cells are protected against changes	*Indicative information*

The spreadsheet cells have different colors or styles that should help the User to understand the function of each cell or when a warning or an error is detected.

The Legend here below indicates the different cells styles that can be found in the spreadsheet, they are described here after starting from the top left up to bottom right:

- **INPUT DATA CELLS**, they are unprotected and used to be filled with input Data: the police is **GREEN** with a LIGHT BLUE/GREY background color.
- **RESULTS DATA CELLS**, they are protected and used to provide the results from calculations, the police is **BLUE** with a WHITE background color.
- **TEXT CELLS**, they are neither INPUT nor RESULTS Cells, the police is **BLACK** with a WHITE background color.
- **WARNING**, when an INPUT DATA CELL has been filled with data outside the values given by the regulatory icing Appendix (C, O or D/P) the police of the cell become **ORANGE** with a YELLOW LIGHT background color.
- **ERROR**, when an INPUT DATA CELL has been filled with erroneous data (e.g. LWC or IWC = 0, invalid drop distribution or other invalid data) the police of the cell become **RED** with a YELLOW background color.
- *INFORMATION CELLS*, under most INPUT DATA cells, a specific information cell indicate the range of the relevant input data values according to the selected regulatory icing Appendix (C, O, D/P), the police is *LIGHT GREY* and Italic with a WHITE background color.

4.1.1. ICING CONDITIONS Color-Codes

The WG-95 selected colors in the ED-103 TABLES 8 & 9 or AS5498 TABLES 1 & 2, these color are recalled here below.

Appendix C	Appendix O		Fully Claciated App D/P
CM	FZDZ < 40	FZRA < 40	
IM	FZDZ > 40	FZRA > 40	

Icing Conditions color-codes Legend

The test matrices of the LW Test Matrix and the App D Test Matrix sheets are using the same color-code rules.

Also the RESPONSE TIME and DISCRIMINATION TIME results provided in the User's Interface sheet are also using the same color-code rules, see Figure on the right.

FIDS RESPONSE TIME		
Maximum Detection Time (LWC)	25,4	(s)
Maximum Detection Time (IWC)	63,3	(s)
FIDS App. O DISCRIMINATION TIME		
LWC contained by drops > 100 µm	0,179	(gr/m^3)
Freezing Fraction with drops > 100 µm	0,521	(--)
Collection Efficiency with drops > 100 µm	0,997	(--)
Discrimination Time App O drops > 100 µm	26,2	(s)
LWC contained by drops > 500 µm	0,125	(gr/m^3)
Freezing Fraction with drops > 500 µm	0,727	(--)
Collection Efficiency with drops > 500 µm	0,997	(--)
Discrimination Time FZRA drops > 500 µm	26,8	(s)

4.2. HIGH LEVEL INPUT DATA

This INPUT DATA TABLE contains two parameters – the Cylinder diameter and the Maximum allowable ice thickness - which are initialized with the ED-103 default values. These values have been defined by the Members of the WG95 and the rationale is given in the Appendix A of ED 103.

Ice Accretion Parameters	Values	Units
Cylinder diameter (representative surface)	25,00	(mm)
Maximum allowable Ice thickness	0,300	(mm)
Cloud Horizontal EXTENT (HE Default Value)	17	

Ice Thickness threshold
Value in mm between 0.1 up to 10 mm
ED103 value = 0.3mm

These parameters can be modified with different values, each cell is self-documented giving the range of accepted values and also recalls the ED-103 default values.

The Figure here above, shows the Ice Accretion Parameter table when the Ice Thickness threshold input cell is selected, a message appears providing information to the User.

The value of the Cloud Horizontal Extent (HE Default Value) is automatically calculated when the Icing Conditions Categories are selected. If different value of HE needs to be specified, the Specific HE input data needs to be filled with the desired value, see here after.

4.3. TEST CONDITIONS INPUT DATA

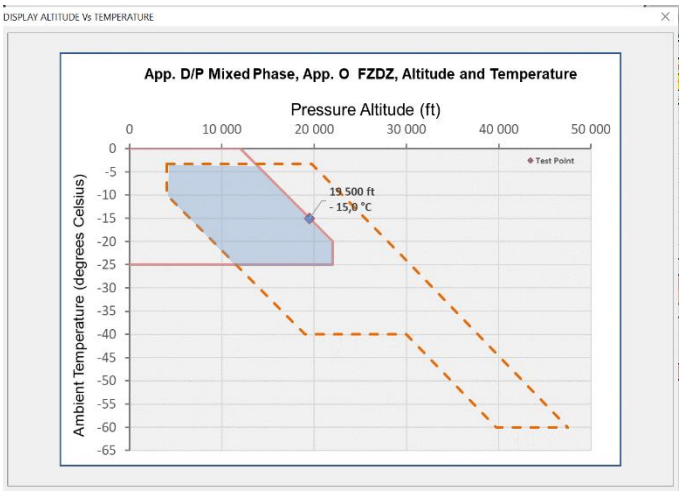
4.3.1. Aircraft and Environmental Parameters

TEST CONDITIONS INPUT DATA		
Aircraft and Environmental Parameters	**Values**	**Units**
Aircraft True Air Speed (V_{tas})	220,00	(knots)
Static Temperature (SAT)	-5,00	(Deg C)
Range of SAT for the selected Altitude value	*-6,49 ≤ SAT ≤ -3,30*	*(Deg C)*
Altitude (Alt)	6000	(ft)
Range of Altitude for the selected SAT value	*4 000 ≤ Alt ≤ 7 379*	*(ft)*
Specific HE *(if different than the default value)*		(NM)
Range of HE for the selected Appendix	*4,15 ≤ HE ≤ 300,0*	*(NM)*

- **Airspeed (TAS)**, range of TAS values between 40 knots and 520 knots (ED-103, section 3.2),
- **Static Temperature (SAT)**,
- **Altitude (Alt), with ED-103 Rev A, the default value shall be 22 000 ft.**
  *The **range of SAT and Altitude** values are indicated according to the regulatory icing Appendix (C, O or D/P). These values are for information only, it does not prevent the User to specify values outside this range. In that case the indicated warning do not prevent the calculation of the results.*
- **Specific HE** ; shall remain empty, except if there is a need to specify an Horizontal Extent different than the HE Default Value defined in the "High Level Input Data" table.
  *The **range of HE** values is indicated according to the regulatory icing Appendix (C, O or D/P). The specific HE value shall be within the indicated range.*

4.3.2. DISPLAY SAT Vs Alt

The DISPLAY function SAT Vs Alt allows the User to Display the regulatory Altitude and temperature envelopes of the selected Icing conditions as shown by the Figure where App O FZDZ condition and Mixed Phase App D/P conditions are selected. The Test Point is then represented on the graph.



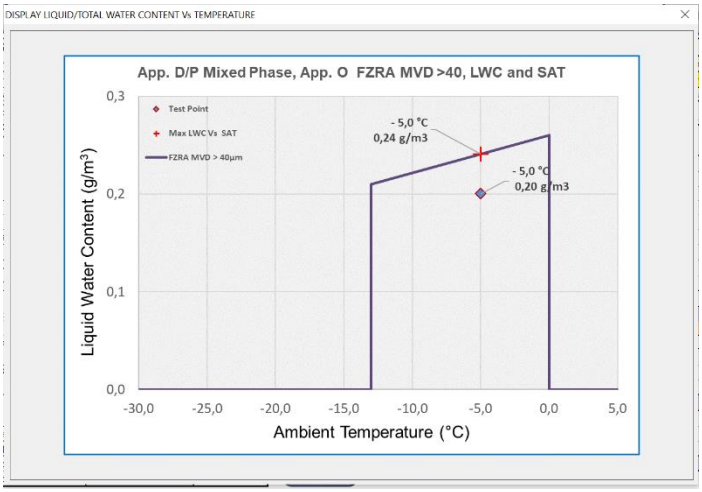
4.3.3. DETECT App. C or App. O Liquid Water Icing Conditions

DETECT App.C or App. O Liquid Water ICING CONDITIONS		
Liquid Water Drop Category	**LW-FZRA**	**Units**
Liquid Water Content (LWC)	0,200	(gr/m^3)
Range of LWC for the selected SAT values	*0,01 ≤ LWC ≤ 0,241*	*(gr/m^3)*
Drops size (MVD)	50	(µm)
Range of MVD for the selected Icing condition	*40 ≤ MVD ≤ 500*	*(µm)*
Drop Distribution	MVD >40	(µm)

- **Liquid Water Drop Category**, select from the list of choice, either LW-CM, LW-IM, FZDZ, FZRA or NO LWC,
- **Liquid Water Content (LWC),**
  The range of LWC values is indicated according to the regulatory icing Appendix (C, O or D/P). These values are for information only, it does not prevent the User to specify values outside this range. In that case the indicated warning do not prevent the calculation of the results.
- **Drops Size (MVD)**.
  The range of MVD values is indicated according to the regulatory icing Appendix (C, O or D/P). The specific MVD value shall be within the indicated range.
- **Drop Distribution**, select from the list of choice, either Dv99 <100 for App C CM or App C IM or MVD <40, MVD >40 for App O FZDZ or FZRA.

4.3.4. DISPLAY LWC Vs SAT

The DISPLAY function LWC Vs SAT allows the User to Display the regulatory Liquid Water Content of the selected Icing conditions as shown by the Figure where App O FZRA condition and Mixed Phase App D/P conditions are selected. The Test Point is then represented on the graph and the MAX LWC value according to the regulatory icing Appendix is also represented for information.



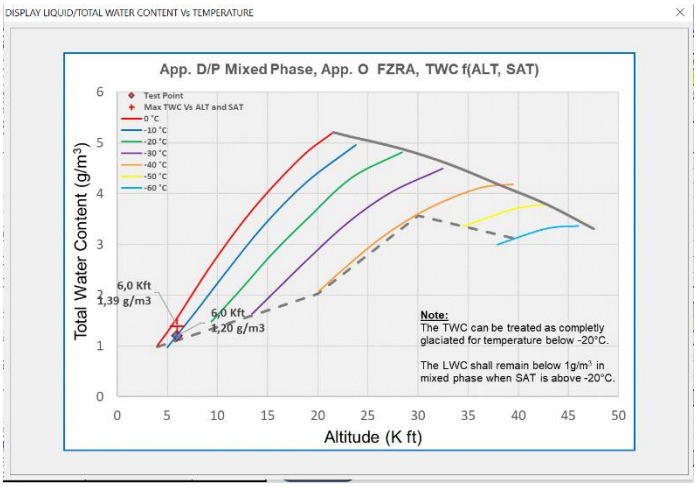
4.3.5. DETECT App. D/P Glaciated or Mixed Phase Icing Conditions

DETECT App. D/P Glaciated or Mixed ICING CONDITIONS		
Appendix D/P Category	**MIXED**	**Units**
Ice Water Content (IWC)	1,00	(gr/m^3)
Total Water Content (TWC)	1,200	(gr/m^3)
Range of TWC for the selected Altitude and SAT values	*0,01 ≤ TWC ≤ 1,389*	*(gr/m^3)*

- **Appendix D/P Category**, select from the list of choice, either MIXED, GLACIATED or NO IWC.
- **Ice Water Content (IWC)**, indicates the content of Ice crystals,
- **Total Water Content (TWC),** is not an INPUT Parameter but it is the result from the calculation TWC = LWC + IWC
  The range of TWC values is indicated according to the regulatory icing Appendix (C, O or D/P). These values are for information only, it does not prevent the User to specify values outside this range. In that case the indicated warning do not prevent the calculation of the results.

4.3.6. DISPLAY TWC Vs Alt and SAT

The DISPLAY function TWC Vs Alt and SAT allows the User to Display the regulatory Total Water Content of the selected Icing conditions as shown by the Figure where App O FZRA condition and Mixed Phase App D/P conditions are selected. The Test Point is then represented on the graph and the MAX TWC value according to the regulatory icing Appendix is also represented for information.



4.3.7. DISCRIMINATE App. O Icing Conditions

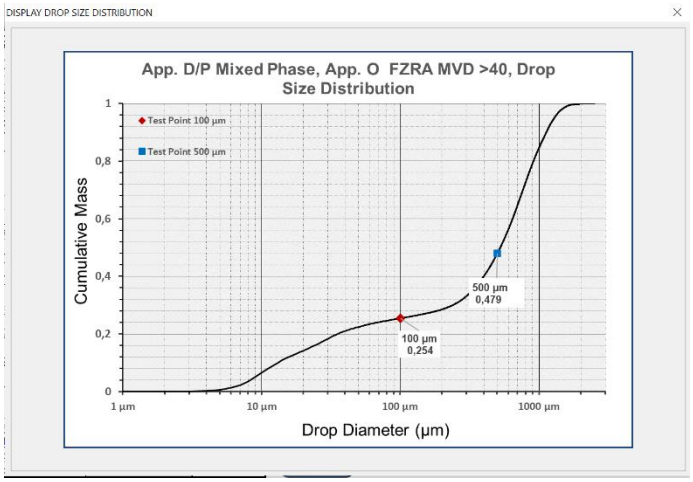
DISCRIMINATE App. O ICING CONDITIONS		
Drop diameter threshold for App. O	100	(µm)
Drop diameter threshold for App. O FZRA	500	(µm)

- **Drop diameter threshold for App. O,** 100µm is the default value but the threshold value can be changed if needed.
- **Drop diameter threshold for App. O Freezing Rain (FZRA),** 500µm is the default value but the threshold value can be changed if needed.

4.3.8. DISPLAY App. O DsD

The DISPLAY function App. O DsD (Drop Size Distribution) allows the User to Display the regulatory cumulative mass of water function of the drop diameter for the selected Icing conditions as shown by the Figure where App O FZRA condition and Mixed Phase App D/P conditions are selected. The Test Point 100µm and 500µm are represented on the graph with the cumulative mass respective values.

For other distribution (e.g. specific to Icing Wind Tunnel drop distribution) refer to the Calculations Sheet, section 5.2.



4.4. Information on the DISPLAY Functions

The DISPLAY functions are activated by clicking on the DISPLAY buttons. Then a Pop-Up window opens with the appropriate graph. To Close the window click on the top right cross [X].

When unappropriated Display function is requested, a message appears to indicate why the command is unappropriated. (e.g. DISPLAY TWC if NO IWC condition is selected.)

Under some conditions, the time to open or close the pop up window can be long, this is usually the consequence of heavy activities on your disk drive. For your information, to generate and display the graph, a temporary GIF file is generated and recorded locally on your disk drive, this temporary file is deleted when you exit the display mode.

4.5. RESULTS OF CALCULATIONS

4.5.1. Aircraft and Icing Parameters

RESULTS OF CALCULATIONS		
Aircraft and Icing Parameters	Values	Units
Aircraft True Air Speed (V_{tas})	113,18	(m/s)
Total Air Temperature (TAT)	1,43	(Deg C)
Liquid Water Content Scale Factor (S)	1,00	(--)
Duration of the Icing Encounter	284,7	(s)
$LWC_{(HE)}$ for the specified Horizontal Extend	0,200	(gr/m^3)
$IWC_{(HE)}$ for the specified Horizontal Extend	1,000	(gr/m^3)
Average Freezing Fraction (η_{avg})	0,504	(--)
Max Collection Efficiency (β_{Max})	0,932	(--)
Max Ice Accretion Rate (IAR)	4,2	(cm/hour)

- **Aircraft True Air Speed (Vtas)**, Converted from knots to meters/second,
- **Total Air Temperature (TAT)**, Calculated from SAT and Mach number,
- **Liquid Water Content Scale Factor (S)**, Calculated from the selected Horizontal Extent (HE),
- **Duration of the Icing Encounter,** Calculated from HE and Vtas,
- **$LWC_{(HE)}$ for the specified Horizontal Extent**, Calculated from $LWC_{(HE)} = LWC * S$
- **$IWC_{(HE)}$ for the specified Horizontal Extent,** Calculated from $IWC_{(HE)} = IWC * S$
- **Average Freezing Fraction (η_{avg}),** Calculated according to ED-103 Appendix A1 method.
- **Max Collection Efficiency (β_{Max}),** Calculated according to ED-103 Appendix A1 method.
- **Max Ice Accretion Rate (IAR),** Calculated from $IAR = (\beta_{Max}\ LWC_{(HE)}\ Vtas\ \eta_{avg}\ ) / \rho_{ice}$

Note: The $LWC_{(HE)}$ and $IWC_{(HE)}$ values are used as input values to calculate the FIDS RESPONSE TIME and DISCRIMINATION TIME.

4.5.2. FIDS RESPONSE TIME

FIDS RESPONSE TIME		
Maximum Detection Time ($LWC_{(HE)}$)	25,9	(s)
Maximum Detection Time ($IWC_{(HE)}$)	63,3	(s)

- **Maximum Detection Time ($LWC_{(HE)}$)**, Calculated according to ED-103 Appendix A1 method,
- **Maximum Detection Time ($IWC_{(HE)}$)**, Calculated according to ED-103 Appendix A3 method,

Note: The IWC line is hidden if NO IWC condition is selected. The LWC line is hidden if NO LWC condition is selected. The LWC and IWC lines are Icing Condition color-coded, see section 4.1.1.

4.5.3. FIDS App. O DISCRIMINATION TIME

FIDS App. O DISCRIMINATION TIME		
LWC contained by drops > 100 µm	0,149	(gr/m^3)
Freezing Fraction with drops > 100 µm	0,616	(--)
Collection Efficiency with drops > 100 µm	0,997	(--)
Discrimination Time App O drops > 100 µm	26,5	(s)
LWC contained by drops > 500 µm	0,104	(gr/m^3)
Freezing Fraction with drops > 500 µm	0,863	(--)
Collection Efficiency with drops > 500 µm	0,997	(--)
Discrimination Time FZRA drops > 500 µm	27,1	(s)

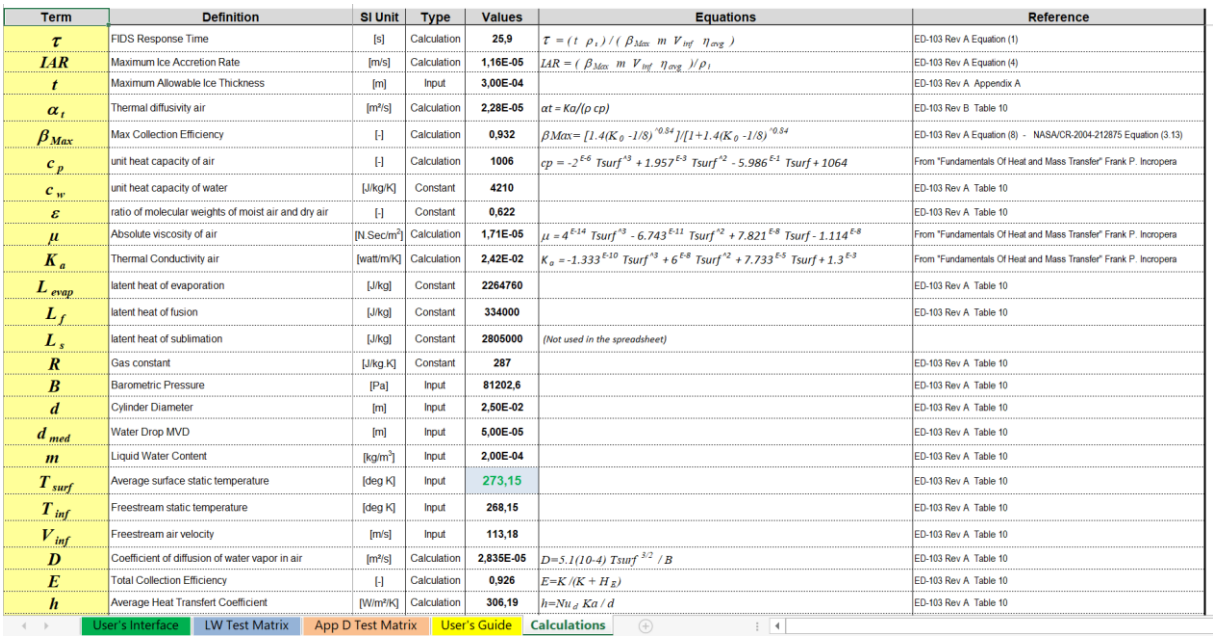
- **Discrimination Time App O drops >100µm**, Calculated according to ED-103 Appendix A2 method,
- **Discrimination Time FZRA drops >500µm**, Calculated according to ED-103 Appendix A2 method,

Note: These lines are hidden if neither FZDZ nor FZRA condition is selected. The 500µm drops lines are hidden if FZRA condition is not selected. The two Discrimination Time lines are Icing Condition color-coded, see section 4.1.1.

5. CALCULATIONS Sheet

The Calculations Sheet contains all the parameters necessary to calculate the RESPONSE TIME and all the associated variables.

Each parameter is documented and equations are provided with references to the appropriate document.



Term	Definition	SI Unit	Type	Values	Equations	Reference
τ	FIDS Response Time	[s]	Calculation	25,9	$\tau = (t \ \rho_i) / (\beta_{Max} \ m \ V_{inf} \ \eta_{evap})$	ED-103 Rev A Equation (1)
IAR	Maximum Ice Accretion Rate	[m/s]	Calculation	1,16E-05	$IAR = (\beta_{Max} \ m \ V_{inf} \ \eta_{evap}) / \rho_i$	ED-103 Rev A Equation (4)
t	Maximum Allowable Ice Thickness	[m]	Input	3,00E-04		ED-103 Rev A Appendix A
α_t	Thermal diffusivity air	[m²/s]	Calculation	2,28E-05	$\alpha t = Ka/(\rho \ cp)$	ED-103 Rev B Table 10
β_{Max}	Max Collection Efficiency	[-]	Calculation	0,932	$\beta Max = [1.4(K_0 \text{ -}1/8)^{*0.84}]/[1+1.4(K_0 \text{ -}1/8)^{*0.84}$	ED-103 Rev A Equation (8) - NASA/CR-2004-212875 Equation (3.13)
c_p	unit heat capacity of air	[-]	Calculation	1006	$cp = -2^{E-6} \ Tsurf^{*3} + 1.957^{E-3} \ Tsurf^{*2} - 5.986^{E-1} \ Tsurf + 1064$	From "Fundamentals Of Heat and Mass Transfer" Frank P. Incropera
c_w	unit heat capacity of water	[J/kg/K]	Constant	4210		ED-103 Rev A Table 10
ε	ratio of molecular weights of moist air and dry air	[-]	Constant	0,622		ED-103 Rev A Table 10
μ	Absolute viscosity of air	[N.Sec/m²]	Calculation	1,71E-05	$\mu = 4^{E-14} \ Tsurf^{*3} - 6.743^{E-11} \ Tsurf^{*2} + 7.821^{E-8} \ Tsurf - 1.114^{E-8}$	From "Fundamentals Of Heat and Mass Transfer" Frank P. Incropera
K_a	Thermal Conductivity air	[watt/m/K]	Calculation	2,42E-02	$K_a = -1.333^{E-10} \ Tsurf^{*3} + 6^{E-8} \ Tsurf^{*2} + 7.733^{E-5} \ Tsurf + 1.3^{E-3}$	From "Fundamentals Of Heat and Mass Transfer" Frank P. Incropera
L_{evap}	latent heat of evaporation	[J/kg]	Constant	2264760		ED-103 Rev A Table 10
L_f	latent heat of fusion	[J/kg]	Constant	334000		ED-103 Rev A Table 10
L_s	latent heat of sublimation	[J/kg]	Constant	2805000	*(Not used in the spreadsheet)*	
R	Gas constant	[J/kg.K]	Constant	287		ED-103 Rev A Table 10
B	Barometric Pressure	[Pa]	Input	81202,6		ED-103 Rev A Table 10
d	Cylinder Diameter	[m]	Input	2,50E-02		ED-103 Rev A Table 10
d_{med}	Water Drop MVD	[m]	Input	5,00E-05		ED-103 Rev A Table 10
m	Liquid Water Content	[kg/m³]	Input	2,00E-04		ED-103 Rev A Table 10
T_{surf}	Average surface static temperature	[deg K]	Input	273,15		ED-103 Rev A Table 10
T_{inf}	Freestream static temperature	[deg K]	Input	268,15		ED-103 Rev A Table 10
V_{inf}	Freestream air velocity	[m/s]	Input	113,18		ED-103 Rev A Table 10
D	Coefficient of diffusion of water vapor in air	[m²/s]	Calculation	2,835E-05	$D=5.1(10\text{-}4) \ Tsurf^{3/2} / B$	ED-103 Rev A Table 10
E	Total Collection Efficiency	[-]	Calculation	0,926	$E=K/(K+H_E)$	ED-103 Rev A Table 10
h	Average Heat Transfert Coefficient	[W/m²/K]	Calculation	306,19	$h=Nu_d \ Ka / d$	ED-103 Rev A Table 10

User's Interface | LW Test Matrix | App D Test Matrix | User's Guide | Calculations

In "Standard Conditions", the User is not supposed to change any parameter, therefore, this Excel Sheet is protected against any change, except for "Expert Users" who have the possibility to change some few parameters as described here after.

5.1. Average Surface Temperature

For "Expert Users" only, the parameter (Tsurf) can be modified if needed for some specific application. The ED-103A default value for Tsurf is 273.15 deg K and should not be changed unless justified.

T_{surf}	Average surface static temperature	[deg K]	Input	273,15

5.2. Optional App O IWT Parameters: MVD, LW-100+, LW-500+

All the Discrimination time calculations are based on the regulatory Appendix O drop distributions (Standard Conditions). It shall be recognized that Icing Wind Tunnel (IWT) are not able to reproduce exactly these water drop distributions, therefore, in order to satisfy IWT operations, the Calculations Sheet provides the capability to enter "Custom Values" with specific MVD, LW-100+ or LW-500+ parameters and calculate the relevant Discrimination Time for this particular App O drop distribution, see Figure below with "Custom Values" in GREEN.

D_{med}	Water Drop MVD (subset of drops > 100 µm)	[m]	Input	2,20E-04	← App O standard value if the custom value is not specified. | Custom Value →	220 µm
m'	LWC contained by drops > 100 µm	[kg/m³]	Input	1,20E-04	← App O standard value if the custom value is not specified. | Custom Value →	0,120 g/m3
D'_{med}	Water Drop MVD (subset of drops > 500 µm)	[m]	Input	6,00E-04	← App O standard value if the custom value is not specified. | Custom Value →	600 µm
m''	LWC contained by drops > 500 µm	[kg/m³]	Input	8,00E-05	← App O standard value if the custom value is not specified. | Custom Value →	0,080 g/m3

WARNING : In "Standard Conditions", the "Custom Values" shall be **EMPTY**

6. MODIFY and RECALCULATE the "LW Test Matrix" Sheet

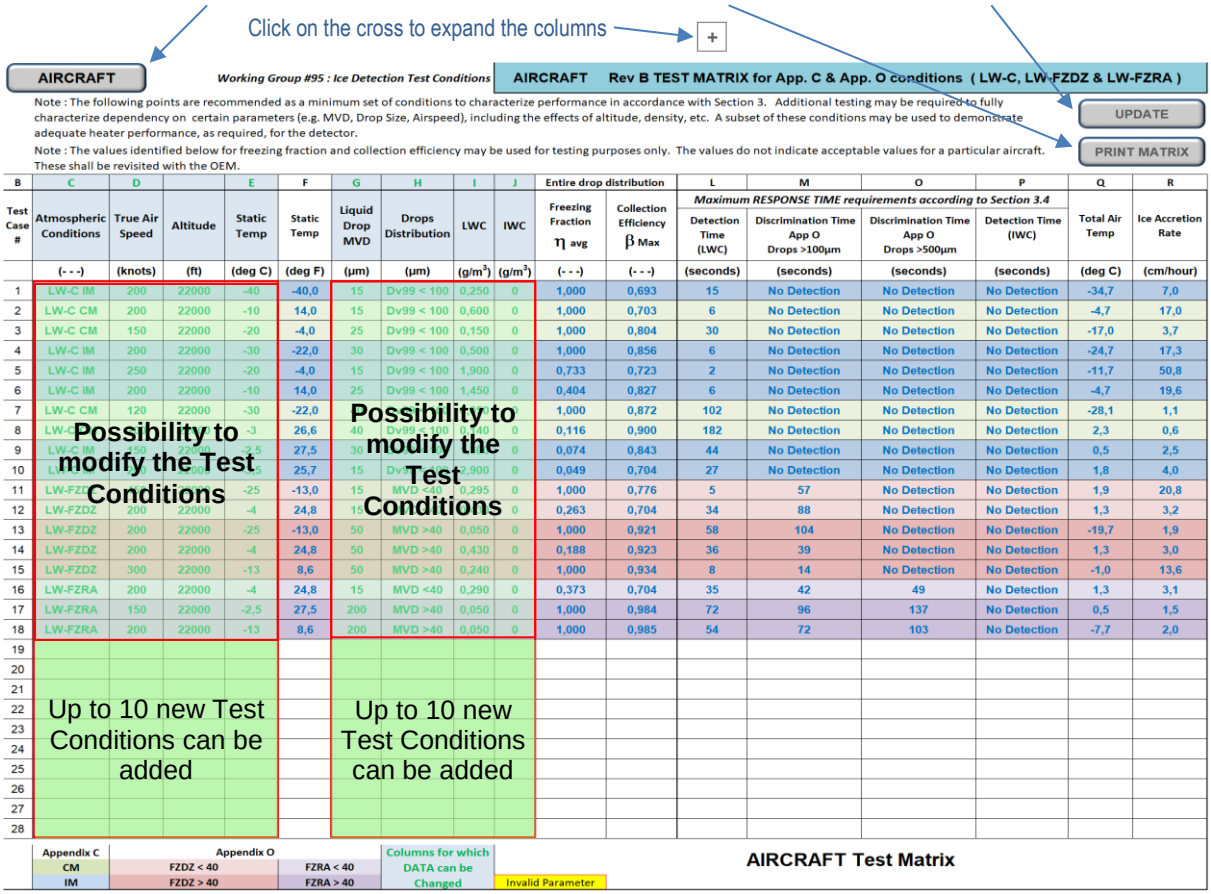
The **LW Test Matrix** Sheet contains all the test conditions of the AIRCRAFT and ROTORCRAFT Test Matrices for **Liquid Water conditions** as referenced in TABLE 8 of ED-103 or TABLE 1 of AS5498.

If the results of the Critical Point Analysis (CPA) require test conditions modifications, the INPUT parameters highlighted by the green rectangles with red borders can be modified according to the results of the CPA. Each input cell is self-documented and is highlighted in YELLOW when filled with invalid parameter.

In this Test Matrix, 10 empty lines are provided if the CPA requires more test points than those specified by ED-103 / AS5498.

The results of the TABLE are NOT RECALCULATED AUTOMATICALLY, it is necessary to press the button "UPDATE" to recalculate the results corresponding to the new INPUT parameters.

Click on the AIRCRAFT / ROTORCRAFT button to display the appropriate Test Matrix.	Click on the PRINT MATRIX button to print the appropriate Test Matrix.	Click on the UPDATE button to recalculate the results and update the appropriate Matrix.



Just above Column L (Detection Time) there is a cross [X], by clicking on the cross the columns expands showing the LW-100+, Freezing Fraction$_{(LW100)}$, Collection Efficienty$_{(LW100)}$, LW-500+, Freezing Fraction$_{(LW500)}$, Collection Efficienty$_{(LW500)}$.

6.1. UPDATE LW Test Matrix and Altitude Options – ED-103 Rev B ONLY

When the UPDATE function is activated, three Altitude options are proposed, Opt 1: Alt = Constant = 22 000 ft , Opt 2: Alt = Maximum Altitude value considering the SAT value, Opt 3: Alt = Altitude value from the list of test points.

For Opt 2, when the SAT value does not allow the calculation of the Altitude, a Warning indicates it.

7. MODIFY and RECALCULATE the "App D Test Matrix" Sheet

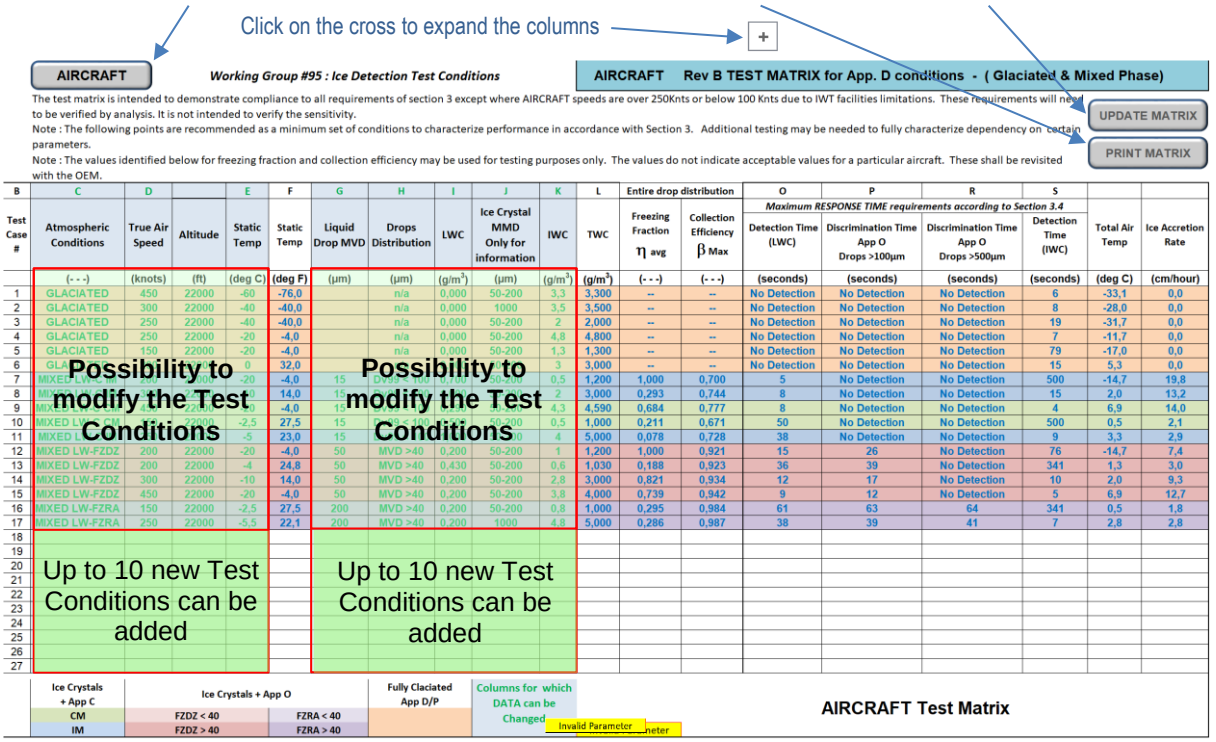
The **App D Test Matrix** Sheet contains all the test conditions of the AIRCRAFT and ROTORCRAFT Test Matrix for **GLACIATED or MIXED conditions** as referenced in TABLE 9 of ED-103 or TABLE 2 of AS5498.

If the results of the Critical Point Analysis (CPA) require test conditions modifications, the INPUT parameters highlighted by the yellow rectangles with red borders can be modified according to the results of the CPA. Each input cell is self-documented and is highlighted in YELLOW when filled with invalid parameter.

In this Test Matrix, 10 empty lines are provided if the CPA requires more test points than those specified by ED-103 / AS5498.

The results of the TABLE are NOT RECALCULATED AUTOMATICALLY, it is necessary to press the button "UPDATE" to recalculate the results corresponding to the new INPUT parameters.

Click on the AIRCRAFT / ROTORCRAFT button to display the appropriate Test Matrix.	Click on the PRINT MATRIX button to print the appropriate Test Matrix.	Click on the UPDATE button to recalculate the results and update the appropriate Matrix.



Just above Column L (Detection Time) there is a cross [X], by clicking on the cross the columns expands showing the LW-100+, Freezing Fraction$_{(LW100)}$, Collection Efficienty$_{(LW100)}$, LW-500+, Freezing Fraction$_{(LW500)}$, Collection Efficienty$_{(LW500)}$.

7.1. UPDATE LW Test Matrix and Altitude Options – ED-103 Rev B ONLY

When the UPDATE function is activated, three Altitude options are proposed, Opt 1: Alt = Constant = 22 000 ft , Opt 2: Alt = Maximum Altitude value considering the SAT value, Opt 3: Alt = Altitude value from the list of test points.

For Opt 2, when the SAT value does not allow the calculation of the Altitude, a Warning indicates it.